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A New Neotenic Plethodont Salamander, with Notes on Related Species

By Sherman C. Bishop [1]

RECENT studies indicate that neoteny among salamanders of the family Plethodontidae occurs more frequently than has been suspected, known examples of this phenomenon having been limited to *Typhlomolge rathbuni*, and to occasional individuals of other species, until 1937, when *Eurycea neotenes* was described from Texas. Since 1937 the unique *Haideotriton wallacei* has been described from Georgia and two additional neotenic species of *Eurycea* have been recognized, *nana* from Texas and *tynerensis* from Oklahoma. The purpose of the present paper is to call attention to additional examples of neoteny in the family and to describe a new species hitherto confused with larval *Typhlotriton spelaeus*.

In several collections of supposed *Typhlotriton spelaeus*, three species were found to be represented, typical *T. spelaeus*, neotenic *Eurycea multiplicata* and a neotenic plethodontid tentatively regarded as a distinct species of *Typhlotriton*. The new species was first detected when a series of specimens from Cherokee County, Kansas, was made available for study by Dr. Hobart M. Smith and Dr. Edward H. Taylor.

The adults of *T. spelaeus* are commonly found in caves, the larvae often in streams in the open. *Eurycea multiplicata* also enters caves, apparently as a larva, and may continue as a neotenic individual, becoming very pale and resembling *Typhlotriton*. The new *Typhlotriton* is often found in open streams where caves are not available and may be quite highly pigmented, but enters caves readily and fades until it is nearly as pale as typical *T. spelaeus*.

Typhlotriton **nereus**, nov. sp.

TYPE.—Collection of Sherman C. Bishop No. 926; a female, total length 96 mm.; from York Spring, Imboden, Lawrence Co., Arkansas.

Fig. 1. *Typholotriton nereus*, n. sp. Sexually mature female; actual length 88 mm. Camden County, Missouri. Drawn by H. P. Chrisp.

PARATYPES.—*Missouri:* USNM [2] Nos. 19778–79, 19781, 19784–85, 19787, Rockhouse Cave, Barry Co.; MCZ Nos. 2269–70, 4607–4608, Wilson's Cave, Jasper Co.; UMMZ No. 77052 (2), Downer's Cave, Sarcoxie, Jasper Co.; SCB (2), Sarcoxie, Jasper Co. *Arkansas:* MCZ Nos. 24061–64, Monte Né, Benton Co.; UMMZ No. 77053 (2), Lawrence Co.; AMNH Nos. 34246–48, 34250, Imboden, Lawrence Co., No. 34152, Carroll Co., Nos. 50040–44, Mammoth Springs, Fulton Co.; KU No. 16199, Lawrence Co.; UAM (2), Sharp Co. *Kansas:* KU Nos. 16036–38, 16043–45, 16350, 16352–54, 16357–60,

near Galena, Cherokee Co., March 26, 1932; EHT No. A 1204 (15), near
Galena, March 26, 1932. *Oklahoma:* UMMZ No. 81481, 8 miles south of
Kansas, Adair Co.; CU No. 434 (8), Adair Co.; SCB (3), Adair Co.
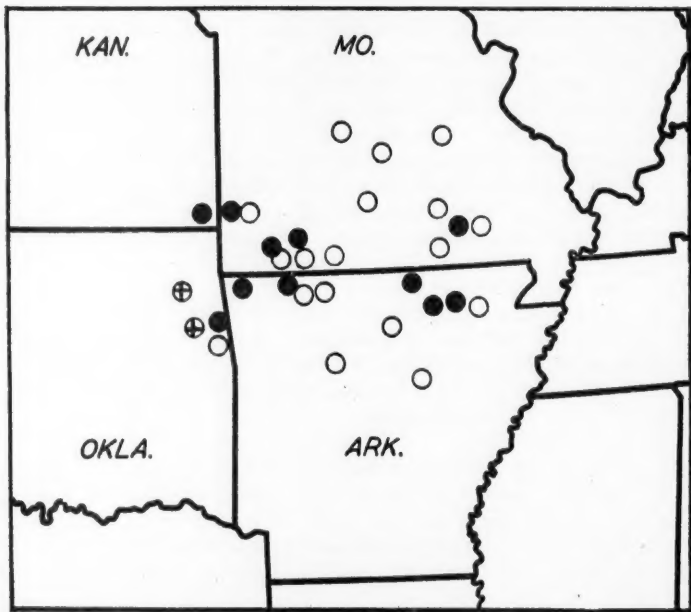
Fig. 2. Map showing the distribution of *Typhlotriton spelaeus* (open circle) and *T.
nereus* (solid circles), the latter apparently limited to the Ozark Plateau. The circles en-
closing crosses in Oklahoma represent literature records of specimens I have not been
able to examine.

RANGE.—*Typhlotriton nereus* is apparently limited to the Ozark Plateau.
The map (Fig. 2) shows the distribution of *T. spelaeus* and *T. nereus* by coun-
ties but does not indicate the specific localities where these species and
Eurycea multiplicata have been found together. In the USNM collections
from Rock House Cave, Barry County, Missouri, *T. spelaeus* is represented
by about a dozen specimens, *T. nereus* by six, and *Eurycea multiplicata* by
five. The three species are also present in various collections from Imboden,
Lawrence County, Arkansas, but whether from the same streams or caves is
not apparent from locality data given on labels. *T. nereus* and *E. multiplicata*
occur together in springs in Carroll County, and *T. spelaeus* and *E. multipli-
cata* together at Eureka Springs, Arkansas.

DIAGNOSIS.—A neotenic species, pigmented when living in the open, pale
when found in caves; 18 or 19 costal grooves and 6 to 7 intercostal folds be-
tween the toes of the appressed limbs; pterygoid teeth usually in patches,
rarely in a single series.

DESCRIPTION OF TYPE SERIES.—The head is somewhat depressed, the sides

behind the angle of the jaws nearly parallel, in front tapering slightly to the bluntly rounded snout; eyes normal in young larvae, their long diameter about twice in the snout, somewhat reduced in the sexually mature individuals and
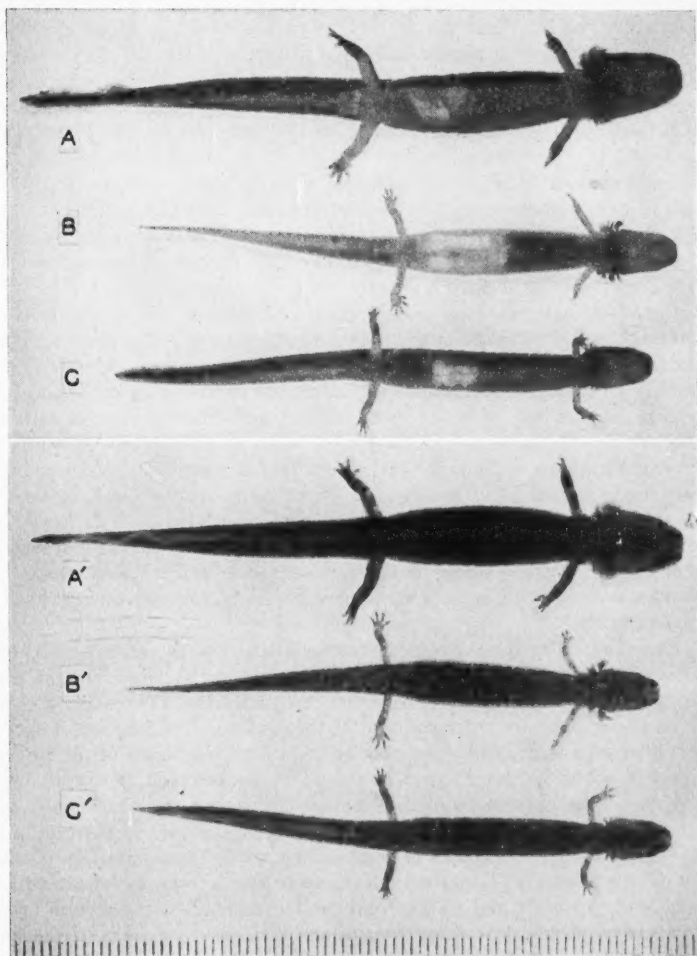
Fig. 3. Ventral and dorsal views of larvae of A, A', *Typhlotriton spelaeus;* B, B', *T. nereus;* C, C', *Eurycea multiplicata.* Rule subdivisions in mm. Photos from life by Arthur J. Smith, through the courtesy of Dr. Robert B. Barden, Cornell University.

contained about three times in the snout; gills lightly pigmented with many long, slender, flattened filaments in immature individuals but greatly reduced in the sexually mature; trunk somewhat compressed, with a mid-dorsal impressed line and 18 or 19 costal grooves, counting one each in the axilla and

groin; intercostal folds 6–7 between the toes of the appressed limbs (in *spelaeus,* costal grooves 16–17 and 2 to 4 intercostal folds); toes 5–4, those of the hind feet 1–5–2 (4–3) in order of length from the shortest; toes of fore feet 1–4–2–3; tail compressed and with a dorsal keel that arises above the insertion of the hind legs and reaches its greatest width at about the distal third; ventral tail keel narrow and confined to the distal half; premaxillary teeth 12 to 20, average 15.8 in seventeen individuals; vomerine teeth in two sinuous lines that converge anteriorly and narrowly separated at the midline; these teeth varying in number from 11 to 15 (17 in one instance) and averaging 13.2 in 20 examples.

In *T. spelaeus,* in a series of comparable size, the premaxillary teeth vary from 18 to 25 and average 20.6, the vomerine teeth from 12 to 17 and average 13.8. In larval *Typhlotriton* the pterygoid teeth form patches in the majority of specimens, in this respect differing from *E. multiplicata,* in which the teeth form single, or at most double, series.

COLOR.—Specimens from open springs and streams are lightly mottled above and on the sides and with at least a suggestion of larval spots forming faintly developed lines on sides. Individuals from caves are often very pale but may be lightly pigmented above, fading out on the sides at the level of the legs and having the larval spots reduced and inconspicuous or lacking (Fig. 3).

Sexually mature individuals reach a length of at least 102 mm. (4 inches) but average considerably smaller. In direct comparison with *T. spelaeus,* this species appears stouter and slightly more pigmented both as larvae in open streams and sexually mature individuals in caves. *T. nereus* is regarded as a distinct species because it occupies the same general territory as *T. spelaeus,* and in some instances the same streams and caves, without evidence of intergradation.

REMARKS.—For the three species under discussion, the graphs presented below (Fig. 4) summarize several structural features and indicate the primary importance of costal grooves and intercostal folds between the toes of the appressed limbs in the separation of these forms. The number of specimens studied is indicated by the italicized figures at the points of the curves. It may be noted that for *T. spelaeus* and *T. nereus,* complete separation may be made on the basis of both costal groove counts and the number of folds between the toes of the appressed limbs; and approximately 72 per cent separation on the basis of counts of premaxillary teeth. Approximately 90 per cent of specimens of *T. nereus* and *E. multiplicata* may be separated on costal groove counts and 93 per cent on the number of intercostal folds. Counts of premaxillary teeth of *spelaeus* and *multiplicata* show no significant differences and the vomerine teeth are essentially the same in all three species.

As indicated above, *nereus* is tentatively regarded as belonging to *Typhlotriton,* mainly because of its great superficial similarity to *T. spelaeus.* The structure of generic significance, and practically the only constant one that separates *Typhlotriton* and *Eurycea,* is the anteriorly attached tongue of the former and the boletoid type of the latter. The tongue is attached anteriorly in the larvae of both and the proper allocation of *nereus* may have to await experimental transformation by means of pituitary stimulation. Another

character that seems to indicate relationship of *T. spelaeus* and *T. nereus* is
the presence of *patches* of pterygoid teeth. In most specimens of *Eurycea*
larvae examined, these teeth are in single or, at most, in double series.
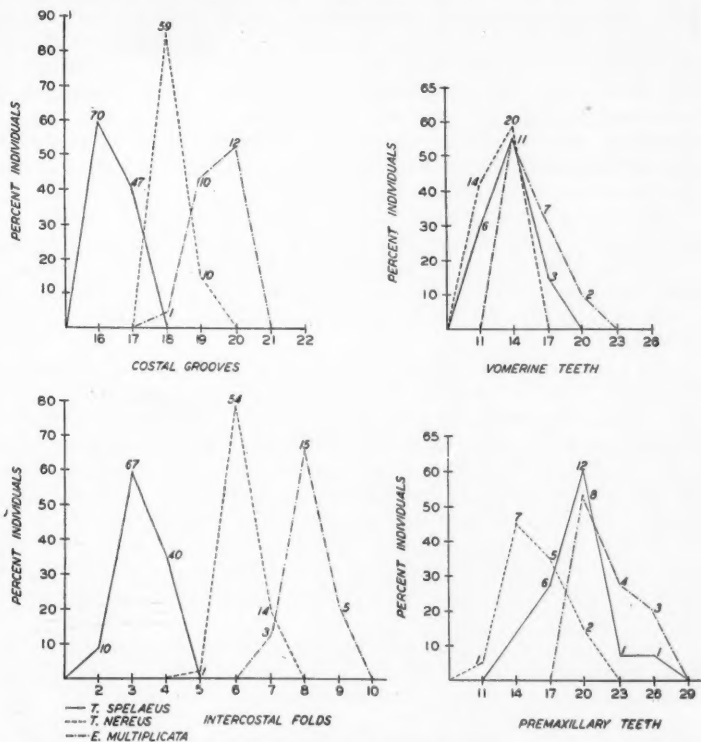
Fig. 4. Graphs showing the distribution of costal grooves, intercostal folds between
the toes of appressed limbs, vomerine and premaxillary teeth in the three species indicated.

The clearing and staining of a number of specimens of both *Typhlotriton*
and *Eurycea* have brought out certain internal structural features that are not
evident in untreated material. *Typhlotriton nereus* and *Eurycea neotenes* pos-
sess gland-like structures in the parotoid region lacking in all specimens of
Typhlotriton spelaeus, *Eurycea multiplicata*, and *E. nana* I have examined.
The presence of these structures suggests a possible relationship to be ex-
plored more fully when specimens are available for treatment by the pitui-
tary technique.

The cleared specimens also reveal the number of rib-bearing vertebrae be-
tween the skull and pelvis and these seem to be constant for a given species.
In descending order they are as follows: *Eurycea multiplicata*, 21; *Typhlo-
triton nereus*, 20; *T. spelaeus*, 19; *Eurycea neotenes* and *nana*, 18.

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Herpetological Notes from Lower California

By Lloyd Tevis, Jr.

IN THE summer of 1941, accompanied by Mr. Garth Jeffers and my brother, Mr. Richard Tevis, I motored the length of Lower California, making two or three stops of a day or more, and at a suggestion that had been made by Dr. Jean M. Linsdale, took advantage of the opportunity offered to collect and study some of the amphibians and reptiles encountered. This paper reports on that collection, which has been deposited in the Museum of Vertebrate Zoology of the University of California. Additional specimens for comparison were loaned by the Museum.

Under each species I have listed the localities of capture, the Museum catalog numbers, and the dates of collection, followed by notes on structure or habits or both. For those species divided into subspecies the assignments of the specimens, as made by me, are indicated by headings. Species considered at greatest length are the ones to which particular attention was given in the field.

The essentials of our itinerary are that we crossed the Mexican border at Tiajuana on May 30, reached Cabo San Lucas on July 3, and embarked from Santa Rosalía for Sonora on July 16. Except for a side trip to Bahía de los Angeles on the Gulf, all observations and collecting were confined to the one road traversing the Peninsula. As the purpose of the trip was not herpetological, time spent in collecting and observation was possible only because of the sacrifices made and the assistance rendered by my companions. Mr. Jeffers' command of Spanish was invaluable. The difficulties of a trip for a low-slung 1941 Ford stationwagon after a winter of torrential rains were mitigated by the friendliness of the people of Lower California and their eagerness to give aid.

I wish to express my gratitude and deep appreciation to my mother and father, who made the trip possible, and to Dr. Jean M. Linsdale for advice and encouragement in the preparation of this report.

Bufo compactilis californicus Camp

Rio Santo Domingo at the Hamilton Ranch, 300 ft., lat. 30° 45′:37242–37243; June 2.

Early in the moonlit night of June 2, Sonoran toads were active on the sandy, brushy area in the vicinity of the Santo Domingo River. Although abundant on dry sand 500 feet or more from the river, none was found on a non-sandy substratum. The toads made considerable noise by continuously hopping at random over the dry leaves under bushes. Some were noted squatting in the shallow water at the river's edge.

Bufo punctatus Baird and Girard

Aguaito Springs, 15 miles E Rosario, 1300 ft., lat. 30° 4′; 37244; June 9. 2 miles NNW Cataviña, 1950 ft., lat. 29° 47′; 37245–37248; June 11.

The red spotted toad from Aguaito Springs was the only individual of this species seen at that locality—a series of spring-fed pools in an arid terrain. Of the four from near Cataviña, two were hopping at night on the dry, sandy floor of an arroyo at least 100 feet from water, and two were squatting in a pool.

Hyla regilla Baird and Girard

Rio Santo Domingo at the Hamilton Ranch, 300 ft., lat. 30° 45'; 37249–37250; June 2.
    Aguaito Springs, 15 miles E Rosario, 1300 ft., lat. 30° 4'; 37251–37256; June 9.

On the night of June 2 multitudes of Pacific tree toads were strung around the sand bars and along the sandy banks of the shallow, widely spread, slow-moving Santo Domingo River. Their croaking was the dominant night sound. When the toads were alarmed, they would swim to and try to hide in the masses of slimy, thread-like, green algae attached to fallen willow branches and other debris. The species was also abundant at night in and around the isolated pools at Aguaito Springs. Individuals beside but not actually in the water, if disturbed, hopped uphill to dry brush cover rather than down into the water.

Dipsosaurus dorsalis dorsalis Baird and Girard

San Ignacio, 600 ft., lat. 27° 17'; 37257–37258; June 21.

Although desert iguanas were seen at various localities from the Vizcaino Desert south, more were encountered on the sandy floor of the San Ignacio arroyo than anywhere else.

Crotaphytus wislizenii Baird and Girard

Medano Blanco, 150 ft., lat. 25° 40'; 37260–37261; June 28. Sand dunes 12 miles SE
    Venancio, lat. 24° 10'; 37262; June 30.

The leopard lizards from Medano Blanco were shot on the sandy, cactus covered Plain of Magdalena. Because of the lack of brush cover there were no hiding places, and the lizards attempted to escape in a characteristic manner. Each ran 50 feet or farther to a spot behind a cactus, crouched there low against the ground, and became motionless, apparently expecting to elude detection thereby, for it then allowed approach to within 3 feet.

The one from the sand dunes southeast of Venancio started up when I was 40 feet distant, ran 100 feet at great speed across the dunes, and disappeared into a low, spreading type of bush. Subsequent search revealed it crouching under cover as close as possible to the sand. I approached to within 3 feet of it in order to see if it would take alarm again. It did not.

Callisaurus draconoides Blainville

C. d. gabbii Cope

2 miles S El Marmol, 2400 ft., lat. 29° 56'; 37263; June 11.

C. d. carmenensis Dickerson

3 miles SE Laguna Seca Chapala, 1900 ft., lat. 29° 22'; 37275; June 12. 25 miles E
    Punta Prieta, 1300 ft., lat. 28° 55'; 37276–37278; June 13. Bahía de los Angeles, lat.
    28° 55'; 37279–37290; June 14, 15.

C. d. crinitus Cope

Sand dunes 1 mile SSE Millers Landing, lat. 28° 29'; 37264–37274; June 17.

C. d. draconoides Blainville

20 miles SE Mesquital, 1000 ft., lat. 28° 4'; 37291–37292; June 18. San Ignacio, 600 ft.,
    lat. 27° 17'; 37293–37294; June 21. 1 mile SW San Ignacio, 600 ft., lat. 27° 17';
    37295–37299; June 21. Santa Rosalía, lat 27° 20'; 37300; June 24. Coyote Bay, 13
    miles SE Mulegé, lat 26° 40'; 37301–37303; June 26. Sand dunes 12 miles SE
    Venancio, lat. 24° 10'; 37304–37311; June 30.

HABITS.—No gridiron-tailed lizards were seen north of Rosario. At that point the road turns abruptly inland. The first were seen inland in the arid,

cardón country about Mission San Fernando. They were plentiful there, especially on sandy ground such as washes and broad arroyos. In general, for that region, wherever the red-flowered tarbidillo grows is a likely place to find the gridiron-tailed lizard. It is striking in appearance when running rapidly ahead of the automobile, for the tail then is curled over the back to expose the vividly black and white ventral bars. Doubtless a predator in pursuit of such a lizard would strike at the tail, which is easily detached, rather than at the partly hidden, drab body.

On being stalked, a lizard shows nervousness by wagging its tail from side to side flat on the sand, then increasing the tempo until the tail is lifted and curled over the back, and away goes the lizard at top speed. Once the tail starts wagging, the collector might as well shoot; the lizard is sure to run. Probably this tail wagging functions to direct a predator's initial attention to the tail.

Sometimes, if I did not walk directly toward a lizard, it allowed a 3-foot approach, so much did it depend on its protective coloration. But if it realized it had been seen, there was no stopping the rush to cover. A lizard once stalked so that it knows itself the object of the hunt is exceedingly wary and intolerant of approach. A fleeing lizard when running through broken brush typically describes a zig-zag course with right-angle turns executed only when on the opposite side of a large rock or bush. The ultimate point of refuge is brush cover at least 50 feet distant. The lizard either goes under the brush at once or, stopping at the edge, depresses the tail and, turning its head to one side, raises up on its front feet in order to see what is behind. Although by depressing the tail the lizard appears to melt into the substratum, it can be found again, unless wounded, if the point at which it stopped is noted. A wounded lizard invariably disappears, presumably by burying itself in the sand.

For a good part of the distance between El Marmol and Cataviña the substratum is all hard-packed sand formed from the weathering of great blocks and columns of granite. There the gridiron-tailed lizard is widespread and individuals were often seen basking in full sun on the top of a block, sometimes as much as 6 feet above the ground. A human intruder within 100 feet could be detected by the lizard, which, if approached, wasted no time in going down the opposite side of the block.

Between Cataviña and Laguna Seca Chapala is rocky country where the species is confined to the washes. In the generally sandy terrain bordering Laguna Seca Chapala and also between Punta Prieta and Bahía de los Angeles of the Gulf the lizards were noted frequently.

At Bahía de los Angeles a colony on a 100-foot wide 400-yard long sand spit projecting into the bay was restricted to the outer third, the only part of the spit on which grew thickets of salt bush. Tidal wrack on the surrounding beach attracted these lizards, many of whom foraged over the beach up to 45 feet from cover and to within 5 feet of the water's edge. But at the slightest disturbance, such as my approach 150 feet or more distant, the beach was astir with a phalanx of lizards racing back to the salt bush. Where a 4-foot vertical wall of hard-packed sand bordered the beach the lizards went up and over it by sheer force of momentum. One lizard failed on its first try. Then, starting from the base instead of distantly, it tried six times in rapid succession, but each time fell back. After this it rested for fifteen seconds,

tried again more calmly, got a hind foot grip on a protruding clam shell, gained the top, and dashed to the brush. The return to the beach by each lizard was cautious, a short rush followed by about four minutes of watching and then another rush.

While foraging on the beach the lizards often jabbed at the sand with their mouths, probably to seize one of the many small insects and crustaceans, or made a 6-inch rush in pursuit of some animal. When not actively foraging, the lizards climbed onto the fish and ray carcasses, gastropod shells, clam shells, turtle carapaces, and pieces of iron that littered the beach and there sunned and watched and sometimes bobbed up and down.

Each individual had an attachment for a particular object. One lizard that I watched for about half an hour ran from the salt bush 25 feet directly to the carcass of a ray and for the remaining time until disturbed by me either squatted on the ray or foraged within 6 inches of it. Occasionally by using the front feet it dug half-inch deep pits at the edge of the carcass in order to get at the beetles feeding on the under side. The top of the carcass was utilized for basking. No other lizard came within 10 feet.

I estimated that each individual had a fairly small range along the axis of the beach, about 50 feet; but in spite of intolerance of one lizard for another there was much overlapping of ranges. In the chases observed it was always a large lizard that pursued a smaller one.

Because the lizards on the sand spit were warier and harder to shoot than were those on the mainland I had to resort to two techniques to obtain specimens:

1. To crash through the brush until a lizard was stirred up. A lizard under cover, in contrast to one in the open, is not likely to run far and therefore can be shot when its position under the brush is determined.

2. To walk along the beach close to the brush. Most of the lizards will run to cover, but a few, particularly those that are far from cover, will stay motionless, relying on their protective coloration. If the collector appreciates this fact, he can spend any amount of time desired studying the beach until the form of a lizard is segregated from the substratum. When the lizard crouches on a mat of dark tidal wrack, as it often does, it can be detected easily. The lizards do not appreciate the fact that their protective coloration succeeds only when applied against the sand.

The general light-gray of the dorsum almost perfectly duplicates the light-gray sand, but a few individuals, always ones found under brush, were conspicuous because they were darkly colored. Various naturalists, among them Schmidt (1922: Plate LI, figs. 2 and 3), have pointed out that the gridiron-tailed lizard has dark and light color phases, and experimental work by Atsatt (1939) demonstrated that they are dark until the temperature rises to 40°C. (104°F), after which the light phase develops. It is likely that the dark lizards I noted were dark because they had not yet ventured into the hot sunlight; and, although the presumed function of the light phase is to prevent extra absorption of heat, at Bahía de los Angeles it also acted to increase the lizard's resemblance to the substratum.

At Millers Landing the situation was reversed. There the fog and ocean breezes were a chilling contrast to the hot, clear climate of the Gulf, the massive dunes were dark-gray instead of light-gray, and, with few exceptions, the

dorsal color of the lizards was dark-gray. The exceptions in the light color phase were strikingly conspicuous. If the predominance of the dark color phase at Millers Landing is attributable only to temperature, the lizard's resemblance to the dark-gray sand was a coincidence resulting from the cooling effect of the ocean, as at Bahía de los Angeles the resemblance to the light-gray sand would be a coincidence resulting from the hot climate of the Gulf.

The cool climate at Millers Landing restricted the period of activity. On June 17 when the fog did not break until 8:30 A.M., the first lizard was seen at 9:05 A.M. Not until 11 A.M. were the lizards out in full numbers, and even then in order to escape the ocean breezes they concentrated on the inland side of the dunes. None foraged on the beach. The lizards were further localized in their distribution, being restricted to the ridges, where the sand, fifteen minutes after the fog broke, was too hot for me to walk on with bare feet. In the depressions, where the sand was cooler at first, the lizards were rarely found.

The 100 road miles along the sandy, rock-strewn Vizcaino Desert were almost uninhabited by the genus. However, the road hugs the foothills where the arroyos, jammed with broken lava, are unsuited for the gridiron-tailed lizard. On the sandy floor of the great arroyo of San Ignacio, which cuts across the Vizcaino Desert, the lizards were abundant.

South of San Ignacio the Gulf shores are characterized by extreme humidity and heat. At Coyote Bay during the night the vegetation was soaked even though the sky was clear, and in the early morning mist clouds rose off the water like steam to drift inland until dissipated by the heat. The lizards there, although abundant, were found only on the sandy, alkaline plain, a fifth of a mile wide, hemmed in between the beach and the volcanic Sierra.

In three respects their habits differed from those at Bahía de los Angeles:

1. They did not forage on the beach proper.

2. They were much less wary. Often they did not run from my approach and would remain in sight even when rocks were thrown at them. Probably the lizards were careless because the covering of large shrubs, such as mesquite, meant that they were always at least near cover.

3. They did not curl their tails over their backs. Mosauer (1936:7) stated that *crinitus* of the sand dunes of the Vizcaino Desert is the only member of the genus that does not curl its tail over its back when running rapidly, and he believed that this habit difference could be used for field identification. My observations indicate that in the southern half of the Peninsula no gridiron-tailed lizard curls its tail over its back.

The first Pacific point after Millers Landing where the road encounters sand dunes is 12 miles southeast of Venancio. These dunes, being south of Magdalena Bay, are not continuous with the dunes of the Vizcaino Desert. The lizards there were scarcer than were the lizards at Millers Landing and, possibly because of the larger areas of brushless sand, were warier. In fact it was harder to collect specimens there than at any other place where I noted these lizards. One feature that made them difficult to find was the presence of a low, thorny, leafless bush which permitted the sunlight to filter to the underlying sand and under which, therefore, the lizards spent most of their time instead of coming into the open.

The Mexican name of the gridiron-tailed lizard in Lower California is *cachorra blanca*, except in the Cape region, where it is known as *cachimba*.
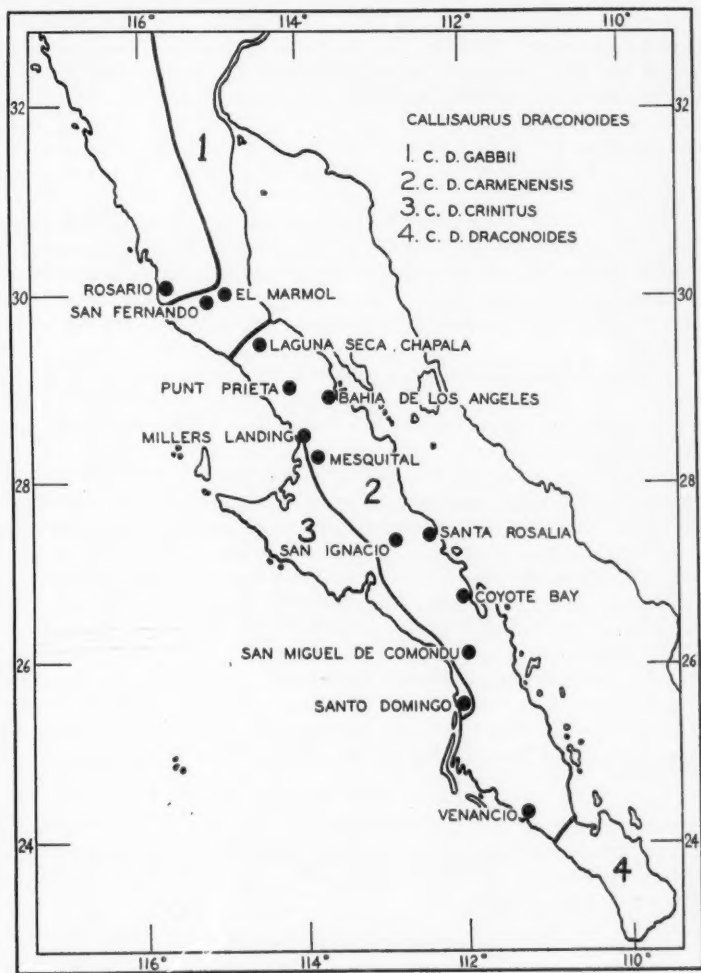
Fig. 1. Distribution of gridiron-tailed lizards, genus *Callisaurus*, in Lower California. Localities shown are mentioned in text.

STRUCTURE.—The eleven Millers Landing specimens from Vizcaino Desert sand dunes within the range of *crinitus* were compared with specimens of *gabbii*, *carmenensis*, and *draconoides*. The chief distinguishing characters of *crinitus* are: (1) three oblique lateral black bars; (2) supralabials produced

laterally so as to form an almost straight line, not a series of curves, when seen from above; and (3) lateral fringe of long spinose scales on the digits.

Of the six males from Millers Landing, one has three bars preceded and followed by a black spot; one has three complete bars; two have three complete bars on one side only; one has two bars followed by a black spot; and one has two bars, the second elongated posteriorly. Hence, the number of bars in *crinitus* is variable. Although no specimen examined, other than *crinitus*, had as many as three bars, this tendency was found at certain localities. For example, two of the males from Bahía de los Angeles have two bars followed by a black spot, and the remainder have the second bar elongated posteriorly.

Mosauer (1936: 5) stressed the straight line formed by the sublabials. Of my Millers Landing specimens only one has this character perfectly developed. A specimen of *carmenensis* from Bahía de los Angeles is indistinguishable as regards this character from most of the Millers Landing specimens, and one from Venancio has a straighter line than does any but one of the latter.

Presence of long digital scales is probably the only consistently diagnostic character; but this is also a matter of degree. All my Bahía de los Angeles and Venancio specimens of *carmenensis* have at least a slight fringe, and some have the scales sufficiently elongated to resemble *crinitus*.

In conclusion, because the facts given above indicate intergradation between *carmenensis* and *crinitus*, I follow Linsdale (1932) in recognizing in Lower California only one species of *Callisaurus* divided into four subspecies: *gabbii* in the north; *draconoides* in the Cape region; *crinitus* on the sand dunes of the Vizcaino Desert; and *carmenensis* in the central part excluding the Vizcaino Desert sand dunes. Apparently the long digital scales of *crinitus* adapt the lizards to the extensive, comparatively permanent dunes of the Vizcaino Desert, while selection preserves the race in this special habitat and limits the area of intergradation to a narrow belt. The sand dunes that extend south along the shore line from the Vizcaino Desert proper to Santo Domingo apparently are inhabited by *crinitus*, for Schmidt (1922) mentions two specimens of *crinitus* in the Biological Survey collection from that locality.

Uta mearnsi Stejneger

Coyote Bay, 14 miles SE Mulegé, lat. 26° 40′; 37259; June 26.

Two Mearns giant utas noted on the hot, vertical, lava cliffs and tiers that front Coyote Bay were adept at leaping across vertical fissures and clinging in an upside down position.

Uta microscutata Van Denburgh

Coyote Bay, 13 miles SE Mulegé, lat. 26° 40′; 37312; June 26.

This small-scaled *Uta* at Coyote Bay was restricted to the jumbles of rocks at the base of the lava cliffs. The lizards leaped rapidly from rock to rock and if close pressed, hid beneath them.

Uta stansburiana Baird and Girard

8 miles SE San Quentín, 40 ft., lat. 30° 25′; 37313; June 4. Bahía de los Angeles, lat. 28° 55′; 37314; June 14.

Only one individual of the brown-shouldered lizard was seen on the small

dunes that fringe the beach at Bahía de los Angeles. Lacking the speed and
protective coloration of the gridiron-tailed lizard it seemed poorly adapted in
comparison for a sand-dune habitat. When disturbed, it ran under a bush,
which it then refused to leave, even though I approached and the bush pro-
vided inadequate cover.

Sceloporus magister Hallowell

S. m. rufidorsum Yarrow

Aguaito Springs, 15 miles E Rosario, 1300 ft., lat. 30° 4′; 37315; June 9.

S. m. monserratensis Van Denburgh and Slevin

45 miles NW San Ignacio, 450 ft., lat. 27° 52′; 37316; June 18. Sand dunes 12 miles SE
  Venancio, lat. 24° 10′; 37317; June 30.

The one from Aguaito Springs was foraging at night on open, bare ground.
It ran to brush cover. On the sand dunes southeast of Venancio rough-scaled
lizards were noted only in the immediate vicinity of wood rat houses, to which
they ran when alarmed.

Sceloporous orcutti orcutti Stejneger

Coyote Bay, 13 miles SE Mulegé, lat. 26° 40′; 37318; June 26.

The one specimen was taken on the rocks at the base of the lava cliffs and
terraces fronting Coyote Bay.

Phrynosoma coronatum (Blainville)

P. c. frontale Van Denburgh

18 miles NW Santo Domingo, 300 ft., lat. 30° 55′; 37319; June 1. Mission Santo Do-
  mingo, 400 ft., lat. 30° 45′; 37320; June 3. 7 miles NNW San Quintín, 75 ft., lat.
  30° 31′; 37321, 37322; June 3. San Quintín, lat. 30° 29′; 37323; June 4. 6 miles
  SE San Quintín, 75 ft., lat. 30° 27′; 37324; June 4. 2 miles SSE Socorro, 100 ft.,
  lat. 30° 15′; 37325; June 6. 5 miles E Rosario, 990 ft., lat. 30° 4′; 37326; June 9.
  20 miles E 3 miles S Rosario, 1500 ft., lat. 29° 56′; 37327; June 10. 30 miles E
  Rosario, 1600 ft., lat. 29° 58′; 37328; June 10. 2 miles NW Punta Prieta, 650 ft.,
  lat. 28° 58′; 37329; June 12. 22 miles E Punta Prieta, 1300 ft., lat. 28° 55′; 37330;
  June 16.

P. c. jamesi Schmidt

Sand dunes 1 mile SSE Millers Landing, lat. 28° 29′; 37331; June 17. 5 miles ESE
  Millers Landing, 100 ft., lat. 28° 28′; 37332; June 18. 4 miles SE El Arco, 1000 ft.,
  lat. 27° 59′; 37333; June 18.

P. c. coronatum (Blainville)

21 miles S Santo Domingo, 100 ft., lat. 25° 20′; 37334; June 28.

HABITS.—The five horned toads from the vicinity of San Quintín and
the northern Santo Domingo were found on flat, sandy ground generally
covered with low bushy growth. The inhabitants of Rosario said that horned
toads are abundant on the sandy ground of the willow thickets. One that I
noted on the arid, maguey-dotted plain above Rosario ran swiftly into a hole
under a maguey and had to be dug out. One of the Millers Landing specimens
was captured on the sand dunes. When pursued it ran to brush cover.

The specimen taken near the southern Santo Domingo inhabited the
Magdalena Plain, where there is considerable cactus but no close brush cover,
and where, therefore, a well-developed temporal crown of spines would be
more needed as a defense against predators than it would in the brushy ter-
rain far to the north.

STRUCTURE.—The sixteen specimens were compared with a series in the
Museum from Lower California, southern California, and Monterey County,
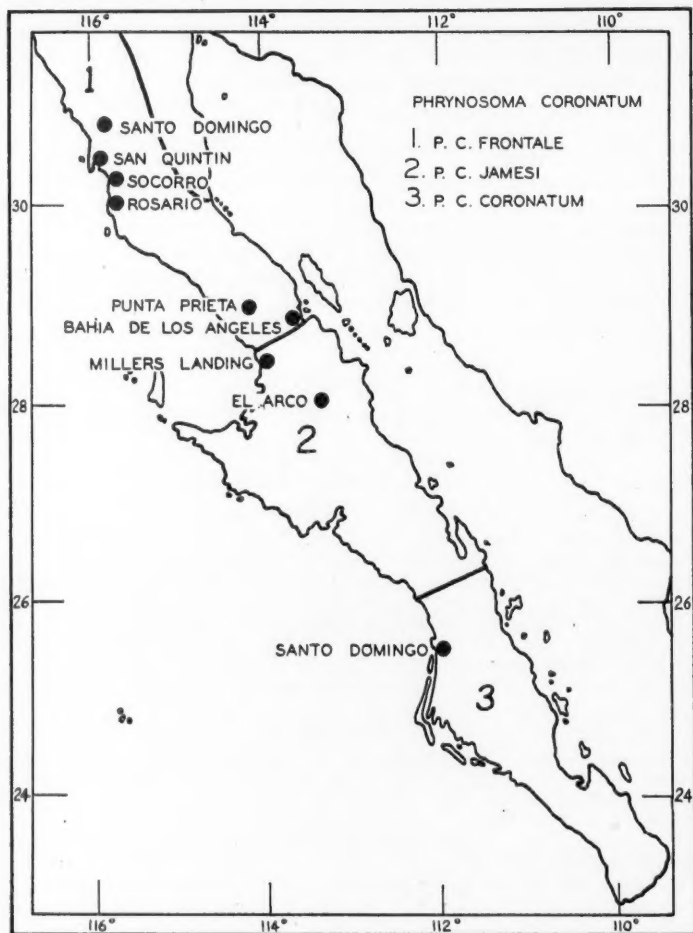
Fig. 2. Distribution of horned toads of the *coronatum* group in Lower California,
exclusive of the extreme northern part. Localities shown are mentioned in text.

in regard to the characters which were listed by Klauber (1936) as differen-
tiating *P. blainvillii* and *P. coronatum*. He reported that several characters,
particularly the nature of the anterior temporals, in the specimens examined
by him showed no intergradation from *blainvillii* in the north to *coronatum* in
the south. He concluded, therefore, that *blainvillii* and *coronatum* are dis-
tinct species, either failing to meet, or overlapping between latitudes 29° and

28° 15'—a 60-mile stretch from which he had no specimens. Four of the specimens to be considered herein were collected within that stretch. In regard to the color of the frontal scales, the two specimens collected near Millers Landing have scales neither as black as in typical *coronatum* nor as drab as in typical *blainvillii*. Both the Millers Landing specimens have slightly outward flaring occipital spines, a condition intermediate between *coronatum* and *blainvillii*. The northern Santo Domingo specimen, two from near San Quintín, the two from Millers Landing, and one from El Arco have interoccipitals less developed than in typical *coronatum* but more developed than in typical *blainvillii*.

As regards the anterior temporals, two specimens from San Quintín have sharp, outward pointing fourth and fifth temporals, which when compared with the posterior three are insignificant in size. A third specimen from San Quintín has blunt, backward pointing fourth and fifth temporals on one side and a fourth temporal only on the other side, all of them of relatively medium size. A specimen from near Rosario has blunt, insignificant but outward-pointing fourth and fifth temporals. A second specimen has only the fourth temporal. From near Punta Prieta there is a specimen with blunt, insignificant but outward pointing fourth and fifth temporals. One of the Millers Landing specimens resembles typical *coronatum* in that it has only a fourth temporal that is sharp, outward-pointing, and prominent. The other Millers Landing specimen has sharp, outward-pointing but insignificant fourth and fifth temporals. This variable condition contrasts with the uniform condition in Alta California and the uniformly opposite condition in southern Lower California.

A Millers Landing specimen has supratemporals intermediate between the enlarged and pointed condition of *coronatum* and the rudimentary condition of *blainvillii*. A Millers Landing specimen also shows an intermediate position of the subrictal.

In conclusion, the facts set forth above indicate that the populations representing *blainvillii* and *coronatum* intergrade through a variable population in the central and north-central part of the Peninsula. I follow Linsdale (1932) in recognizing only one species in the coastal region from San Francisco Bay to the Cape region of Lower California, namely *Phrynosoma coronatum*. I have not had material to study the question of the distinction between the races *blainvillii* and *frontale*. Therefore, I have assigned specimens from northern Lower California to the race *frontale* in accordance with the treatment given them by Klauber.

Cnemidophorus hyperythrus (Cope)

C. h. beldingi (Cope)

Hamilton Ranch, 350 ft., lat. 30° 45'; 37341–37344.

C. h. schmidti (Van Denburgh and Slevin)

Coyote Bay, 13 miles SE Mulegé, lat. 26° 40'; 37345–37352. San Miguel de Comondú, 1000 ft., lat. 26° 4'; 37353; June 28.

HABITS.—At the Hamilton Ranch, orange-throated racerunners were abundant on the uncultivated hillsides, where a prickly, xerophytic type of mixed brush gave dense cover. The lizards lived in holes whose entrances

measured about $1\frac{1}{2}$ inches wide and 1 inch high, and in the early morning
they were often seen pushing out earth with the front feet from within these
holes. They were most active in the morning and early afternoon, when they
were foraging under the edges of the brush clumps. If disturbed, they took
refuge either in the holes or brush. The conspicuous bright yellow dorsal
lines tended to obliterate the body outline of a motionless lizard.

The racerunner and the gridiron-tailed lizard were the two most fre-
quently seen reptiles on the Peninsula. Often they were abundant at the same
locality, as at Coyote Bay, but whereas the gridiron-tail would venture into
the open, the racerunner always stayed under cover.

STRUCTURE.—The four specimens from the Hamilton Ranch when con-
trasted with the others suggest a subspecific differentiation as pointed out by
Linsdale (1932) but denied by Burt (1931).

The Hamilton Ranch specimens have three middorsal lines, the median
one faint. In three of them the granules separate the second supraocular
from the frontal; in one the granules extend to the posterior margin of the
second supraocular.

Of the Coyote Bay and Comondú specimens five have a single middorsal
line forked anteriorly, two have two middorsal lines, and one has three mid-
dorsal lines, the median one faint. In one specimen the granules separate the
second supraocular from the frontal; in seven the granules do not extend be-
yond the middle of the second supraocular; in two the granules extend to the
posterior margin of the second supraocular.

Cnemidophorus labialis Stejneger

8 miles SE San Quintín, 200 ft., lat. 30° 27'; 37335; June 4. 2 miles SSE Socorro, 100
   ft., lat. 30° 15'; 37336–37339; June 6. Sand dunes 1 mile SSE Millers Landing, lat.
   28° 29'; 37340; June 17.

HABITS.—During a two-day stay on the narrow ocean-fronting plain 2
miles south-southeast of Socorro I concluded that the striped racerunners
there were much less abundant than were the orange-throated racerunners at
the Hamilton Ranch. A peculiarity was that the lizards were to be found
only at certain spots of about 100 feet in diameter that seemingly did not
differ in vegetation and substratum from the remainder of the area. At that
site the lizards inhabited sandy to powdery light-colored soil which did not
have a hard surface and which was kept slightly damp by the fog.

The striped racerunners lived in holes similar to the ones used by the
orange-throated racerunners and did not venture out until the air had warmed.
On June 6, when the fog broke at 11:30 A.M., the first racerunners
were seen at 10:45 A.M. They were most in evidence, however, at 4:25 P.M.,
when the fog began to return, for they were then entering their holes. It may
be that this species has its holes distributed in colonies, in which case the
lizards would be most concentrated and in evidence at the time of entering
and leaving the holes. The holes are blocked at night with earth pushed out
from within by the front feet.

In the afternoon when the temperature was dropping, the lizards, in order
to get in closer contact with heat from the ground, pressed their ventral sides
into the powdery soil and spent thirty seconds moving about in circles while
shivering the body and undulating the tail. Like the orange-throated race-
runners they foraged under or close to brush and stopped often to make a

single downward jab with the mouth at the ground or into a hole. The neck then was slightly arched.

The specimen from 8 miles southeast of San Quintín was taken on rocky, hilly ground about 3½ miles inland from the ocean. The specimen from Millers Landing inhabited sand dunes. It was shot while foraging under brush in a depression of the dunes.

The brilliance of the ventral blue coloration is soon lost in formalin.

STRUCTURE.—The Socorro specimens agree closely with the description given by Burt (1931) in regard to the chief distinguishing characteristics: (1) anterior nasal in contact with second upper labial; (2) four supraoculars; (3) granules not extending forward beyond the middle of the third supraocular; (4) two frontoparietals; (5) femoral pores 11 to 14; (6) three middorsal lines; and (7) ventral plates brilliant blue in color.

The specimen from Millers Landing agrees in all these respects except that the anterior nasal is not in contact with the second labial, and it has 15 femoral pores.

The specimen from 8 miles southeast of San Quintín is especially interesting in that it deviates toward *C. hyperythrus,* in having the anterior nasal not in contact with the second upper labial; three supraoculars; the granules separating the second supraocular from the frontal; the transverse median suture on the frontoparietal extending only across the posterior half of the shield; 17 femoral pores; the median dorsal lines united posteriorly into one; and a faint suggestion of orange color on the ventral surface of the throat. The partly split frontoparietal and the mainly blue ventral coloration are the only reasons for referring this specimen to *C. labialis.* It suggests, but of course is insufficient to demonstrate, intergradation or hybridization between *labialis* and *hyperythrus.*

Thamnophis hammondii (Kennicott)

Rio Santo Domingo, 1 mile WNW Hamilton Ranch, lat. 30°45'; 37354; June 2.

The two-striped garter snake was noted in the middle of the day on an exposed sand bar of the river with 20 feet of slowly flowing water between it and the closest bank. When alarmed it slid directly into the water.

Crotalus ruber (Cope)

18 miles N. of Rosario; June 5 (specimen not collected).

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MUSEUM OF VERTEBRATE ZOOLOGY, BERKELEY, CALIFORNIA.

Certain American Geckos of the Genus *Tarentola*

BY ARTHUR LOVERIDGE

WHILE revising the geckos of the Old World genus *Tarentola*, it became necessary to enquire into the status of two members described from the New World, viz. *americana* (Gray) and *cubana* (Gundlach and Peters).

These have in common a character that distinguishes them from all African *Tarentola*, for in both the ear-opening is entirely surrounded by projecting granules, though less conspicuously so in the young where they are not always clear. Of the African forms some such as *delalandii* and *m. mauritanica* exhibit no denticulation about the ear-opening whatsoever, others like *m. deserti* and *neglecta*, both of the Algerian Sahara, now and then produce individuals with a feeble denticulation on the anterior border only; in *a. ephippiata* anterior denticulation may be both absent and well defined in specimens from the same locality, while in *a. annularis* of Egypt there is almost invariably a prominent denticulation anteriorly. Thus we find nothing approaching the condition found in *americana* and *cubana*.

T. americana was described as from New York; the type was later renamed *milbertii* by Duméril and Bibron. Boulenger (1893: 204), after re-examining the type in the Paris Museum, and apparently relying on his memory regarding the type of *cubana* (which he had examined in Berlin nearly a decade before), says that *americana* unquestionably represents a valid species.

He further states that both *americana* and *cubana* agree with *delalandii* of the Canary Islands in lacking what he calls a "supraorbital bone." It is true that *delalandii*, a dwarf species, exhibits a flexible "eyebrow" devoid of supraorbital ossicles, but *cubana*, of which the Museum of Comparative Zoology possesses a fine series assembled by Dr. Thomas Barbour, exhibits this condition only in young examples. Thus of our seventeen *cubana* from Cuba and the Bahamas, only the nine smallest (32–53 mm. from snout to vent) are without supraorbital ossification, two others (51–53 mm.) show signs of it, while the six largest (85–113 mm.) are very definitely ossified. The same situation is to be found in *m. mauritanica* but, in the absence of juvenile material, I am unable to say whether this age difference is common to all members of the genus in which the adults exhibit ossification.

The length of the mental in relation to its breadth is highly variable in all species and fails to distinguish them; Boulenger measured mental width at its middle, I prefer to take the greatest width. I might mention that when Boulenger gives the number of longitudinal rows of tubercles on the back, he

means dorsum only, ignoring the dorsolateral or flank rows, which most subsequent authors have counted. Thus the sole remaining character allegedly distinguishing *cubana* from *americana* is the degree of keeling exhibited by these tubercles. In the former they are undoubtedly strongly keeled, in the latter Duméril, Bibron and Boulenger are agreed that they are feebly keeled or almost smooth. Much may depend on the state of preservation for in an analogous case involving an East African gecko (*Hemidactylus gardineri*) in which the tubercles are strongly keeled, an ancient and somewhat macerated individual received from the Berlin Museum was long an enigma on account of the feeble keel of its enlarged tubercles. As I am unaware of any record of a second example of *americana* during the century or more that has elapsed since its description, it seems certain that a reëxamination of the type, in the light of recent knowledge, would show that *cubana* must be regarded as a synonym. It is in the hope that this matter may receive attention that it is brought forward at this time.

Tarentola americana (Gray)

Platydactylus americanus Gray, in Griffith, Animal Kingdom, 9, 1831: 48. "New York." (Type in Paris Mus.; Milbert don.)

Platydactylus Milbertii Duméril and Bibron, Erpet. Gén., 3, 1836: 325. "New York." (Substitute name for *americanus*.)

Platydactylus (*Tarentola*) *americanus* var. *cubanus* Gundlach & Peters, Monatsb. Akad. Wiss. Berlin, 1864: 384. Cuba.

When the first of his famous catalogues went to press, Boulenger (1885: 195) had no material; two years later (1887: 489) this was remedied by a very brief description. The following standardized description is based on the seventeen specimens in the Museum of Comparative Zoology from the localities stated below.

DESCRIPTION.—Snout rounded, slightly or considerably longer than the distance between the eye and ear-opening; latter moderate or large, vertically oval, both its anterior and posterior border with, rarely without, denticulation formed by small conical tubercles, its vertical diameter from a third to half that of the orbit; orbits separated across crown by 13–17 scales; supraorbital ossicles absent in young (under 53 mm. from snout to anus), present in adults; rostral nearly, or twice, as broad as high, with median cleft at least indicated above; granules on snout flattish in young, usually convex in adults, smooth, subequal to those on occiput, much larger than the granular scales on back; nostril between rostral, first labial and 3 nasals, the anterior in contact with, or separated from its fellow by 1, rarely 2, granules; upper labials 7–10; lower labials 6–9; mental, at its broadest, from 1.25 to 1.5 times as long as broad, flanked on either side by 2–3 chin shields, which are much larger than the gular scales and usually separated, rarely in contact, on the median line; sides of neck with conical and spinose tubercles in adult, flattish in young.

Back covered above with small, unequal, smooth (young) or rough (adult), juxtaposed scales intermixed with 16–20 longitudinal rows of large, oval, strongly keeled tubercles; forearms and hind limbs with similar tubercles; ventral scales much larger than dorsal, imbricate; limbs short, stout, the adpressed hind limb reaching the elbow or barely to the axilla; subdigital

lamellae 9–15 actually under the first toe (+ 1–4 on palm at base), 14–18 under the fourth; tail depressed, verticillate, covered above with small, smooth, or occasionally keeled, scales and 6 (3+3) or sometimes at base 8 (4+4) rows of flattish and smooth (young) or keeled (adult) tubercles, below with irregular imbricate scales, every third row, corresponding with a verticil, being enlarged; on either side of base of tail in both sexes a single row of 2–4 white, tooth-like tubercles; length of tail slightly shorter or slightly longer than the length of head and body.

COLOR.—Above, grayish to pale reddish brown; crown with brown lines; usually from nostril through eye to shoulder or beyond, a reddish brown streak; back with more or less distinct broad brown cross-bars; limbs barred or spotted with brown; tail with 7–8 brown cross-bars as broad as the light inter-spaces which separate them.

SIZE.—Total length of a ♂ (M.C.Z. 11872), 189⁺ (113+76˙) mm., the tail regenerating. The type of *americana* (Paris Mus.) said to be 207 (99+108) mm., its tail obviously the original.

MATERIAL.—*Cuba:* Santiago (MCZ 6919); Cabo Cruz (MCZ 8506); Puerto Escondido (MCZ 9435); La Patana (MCZ 11871–80); Santiago (MCZ 19770); Cienfuegos near Soledad (MCZ 43801). *Bahamas:* Exuma North Cay (MCZ 12330); Andros Id. (MCZ 19566).

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MUSEUM OF COMPARATIVE ZOOLOGY, CAMBRIDGE, MASSACHUSETTS.

Spring Emergence of Painted Turtle Hatchlings

By NORMAN HARTWEG

IN the late afternoon of June 8, 1941, Dr. W. H. Burt of the Museum of Zoology, University of Michigan, noticed a female painted turtle (*Chrysemys picta marginata*) laying eggs on a sandy knoll about 5 miles south of Ann Arbor, Michigan. Dr. Burt watched the turtle deposit six eggs, noting that the eggs were laid at intervals of from 25 to 73 seconds and that after each egg was laid, the turtle thrust a hind foot into the nest. Dr. Burt left the site after the egg-laying was apparently finished, and returned 20 minutes later and found the nest covered with earth. Over the top lay five small sticks, each somewhat smaller than an ordinary lead pencil. The mother was nowhere to be seen.

After Dr. Burt showed me the location of the nest I sank a tube of ⅜-inch mesh hardware cloth into the ground around the nest to entrap the hatchlings

when and if they emerged. The tube was closed at one end, and was 1 foot long and 8 inches in diameter. The tube was carefully worked into the ground to a depth of about 6 inches, leaving an equal amount projecting above.

During the late summer and autumn, Dr. Burt and I examined the tube several times for possible hatchlings. The snows came and the ground froze hard without any turtles appearing on the surface.

In the middle of March of the following spring (1942), on one of the first warm days of the season, the nest location was revisited, the tube was removed and the nest carefully opened and at a depth of 3 inches four hatchlings (free from their shells), all facing upward, were uncovered. The earth, although not frozen, was packed quite solidly about them and no air spaces or pockets were observed. Immediately beneath the turtles were two unruptured, infertile eggs. The ground was unpleasantly cold to the touch, and nearby ponds were skimmed with ice.

None of the hatchlings showed any signs of movement until they had been in the direct rays of the sun for about 15 minutes, when two began moving their legs slowly. The other two did not respond and were taken to the laboratory where they were found to be dead. There was no egg-tooth on any of the four turtles and the umbilical scar was well-formed in all.

To determine the prevalence of wintering over in this region another site was chosen near the University where evidences of painted turtle nests had been observed in the past. With the enthusiastic permission of the owner, Dean Furstenberg, of the University of Michigan Medical School, a hardware cloth fence was erected on his property, which borders the Huron River, about 2 miles from Ann Arbor. The fence was 4 inches high, about 600 feet long and bordered the base of a flat-topped gravelly knoll that descends gently to the water edge. The position and shape of the fence (roughly T-shaped) were designed to prevent the hatchlings from reaching the water.

During late March and early April of 1942 the site was visited at irregular intervals for the weather was intermittently cold and warm and the ground was covered with snow part of the time. From April 7 to April 24 the site was visited at least once and usually three times daily.

The first turtles, in a group of five, were found along the fence on April 17 at 3 P.M. (No turtles were observed the day before at 2 and 6 P.M.) A few minutes later a single hatchling was found about 18 inches from the group of five. An opening in the ground was discovered about 3 feet from the fence, and judging from the grouping of the turtles, and from the moist condition of the soil within the opening and that adhering to the head and carapace of the hatchlings, it is probable that all came from the same nest. There were many shell fragments in the nest, but no whole shells. Apparently, then, at least five and probably six eggs had been laid in the nest and over-wintering was without fatality. At the time of the discovery the air temperature was 60°F. and the soil at a 3-inch depth was 74°F. None of the six hatchlings bore the egg-tooth.

On April 18 a hatchling, bearing the egg-tooth, was observed crawling along a section of fence at right angles to the adjacent section of shore. The spot where the turtle was observed as well as the turtle itself were marked in

hopes of determining rate of movement toward the water. A subsequent search
for this turtle, about 15 minutes after the original observation, failed to reveal
it. Three days later, April 21, it was found under a small mound of loose earth
within a few inches of the original marker.

On April 19 another hatchling was found along the fence, a few feet from
a fresh nest opening. This nest contained shell fragments and a dead hatch-
ling. Although 22 more hatchlings were found between April 19 and 24, no
more nests were located.

In all, 29 hatchlings were found between April 17—very probably the
earliest emergence date for this site in 1942—and April 24. Of these, four
bore the egg-tooth; the umbilical scar was well-formed in all except one in
which the retraction of the yolk sac had been incomplete; one was found dead
in the nest.

No more observations were made until April 30, on which date four hatch-
lings were found scratching at the fence. On May 1 another was found and
on May 2 another. Frequent, but not daily, observations were made until
May 15, but no young were found after May 2. The total number of hatch-
lings observed was 35, and 29 of these were found between April 17 and 24.

Measurements are summarized as follows:

	Carapace length, mm.	Carapace width, mm.	Plastral length, mm.	Height mm.	Weight g.
Largest	28.0	27.0	26.3	13.4	4.3
Smallest	21.1	20.6	20.1	10.5	2.0
Average	24.7	23.4	23.0	12.0	3.0

The weights of seven hatchlings were not used in the table for they were
dead before weight could be obtained. Dessication is rapid after death and
is probably the cause of death if the hatchlings are unable to reach water
within a certain time. The seven dead hatchlings ranged in weight from 1.6 g.
to 2.9 g.—all below the average and three below the range of the live weight
of the group. Some, of course, may have been imperfectly developed.

Thus some hatchlings not only over-winter in the nest, but emerge in the
spring when the soil has been sufficiently softened by rains, and when, appar-
ently, the soil temperature at nest depth rises high enough to be conducive to
activity. No turtles were found when the soil temperature was below 55° at a
depth of 3 inches. On the date of the first emergence, April 17, the soil tem-
perature was 74° at 3 inches; air, 60° F. On April 21, when four hatchlings
were found, the soil and air temperature were 66°F. and 62°F., respectively.
On the 22nd when six were found the temperatures were 68°F. (soil) and
69°F. (air). In clayey soils in a dry spring-season many hatchlings un-
doubtedly become entombed.

Adverse ground conditions in late summer or fall may prevent hatchlings
from emerging and force them to remain in their nests until the advent of
ground softening rains and warm weather the following spring. Indeed the
over-wintering of the four turtles hatched from eggs laid as early as June 8,
1941, seems to suggest that some mechanical barrier prevented emergence the
previous fall. Late egg-laying and consequent late hatching probably has lit-
tle to do with over-wintering in this area.

MUSEUM OF ZOOLOGY, UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN.

Further Notes on Fishing Mortality and Effort [1]

By William E. Ricker

Introduction

R ECENTLY Dr. Milner B. Schaeffer (1943) has made a contribution to
our knowledge concerning the relationship between fishing effort and fish
mortality. His results lead him to suggest that parts of the writer's 1940
paper, on the same general topic, stand in need of revision. Though the basis
of this criticism is apparently Schaeffer's misunderstanding of the definition
of "uniform recruitment," the need for revision is a real one. A number of
developments have made this clear. In addition to Schaeffer's work, an in-
consistency has been found by Mr. Ralph P. Silliman, in the course of recent
efforts to apply the formulae to a west-coast fishery, and another was adum-
brated in some correspondence from Mr. Michael Graham. What has done
most to clarify the various problems in the writer's mind, however, is the
perusal for the first time of the text of Baranoff's (1918) pioneer work in this
field, in which the "modern theory of fishing" appears, practically in its pres-
ent form, and applied to the plaice fisheries of the North Sea.

The mistakes in the 1940 paper could equally well be regarded as approxi-
mations. Considered in that light, they are sufficiently close to reality that
none of the general conclusions based on them are invalidated when a more
rigorous treatment is applied to the same questions. Nevertheless it seems
worth while to take this opportunity of developing more exact calculations,
since it is conceivable that the approximate methods may not always be
serviceable. In addition, it will be useful to give a resumé of the various
concepts used by Baranoff and some later writers, with their mutual interrela-
tionships in various types of fisheries, and to develop these relationships some-
what farther than they have yet been carried.

In the earlier paper two types of fish population were set up for analysis,
and these will still serve as a useful point of departure. In populations of type
I natural mortality and recruitment were presumed to be negligible during
the fishing season. In type II both natural mortality and recruitment were
present, the latter occurring at a uniform rate throughout the season—which
meant the same absolute number of recruits added per day. Schaeffer (1943)
has treated fisheries in which recruitment is absent, but natural mortality is
present. We will call this situation type IB, assigning the modified label IA
to the original type I. It would seem that type IB populations will rarely be
found in nature, for if fishing extends over a period long enough for natural
mortality to be appreciable, there will usually also be appreciable recruitment
during that period. Nevertheless, a population of this sort may sometimes be
under consideration when a group of tagged or marked fish is being studied,
and consequently it is of some practical importance in research. It may be
observed too that the fisheries postulated in a paper by Thompson and Bell
(1934) are essentially of type IB; for in them recruitment (and, as we shall
see, growth also) takes place exclusively at a time of year other than that
during which fishing and natural mortality occur. This anomaly makes

Thompson and Bell's analysis much less realistic than Baranoff's, though in some ways they parallel him closely.

The type II population of 1940 may also conveniently be divided into two groups. The first of these, IIA, is a population in which recruitment, occurring at a uniform (linear) rate throughout the year, is exactly balanced at all times by an equal number of deaths; a situation which can exist only if both recruitment and mortality rate have been unchanged for some years, so that the population is stabilized. This is the first situation postulated by Baranoff in developing his theoretical analysis, and he was convinced that the North Sea plaice population, in the first decade of the century, bore a close resemblance to this ideal. In type IIB populations, recruitment is uniform, but it is not exactly balanced by mortality, so population may be either increasing or decreasing.

The four population types may be summarized as follows:

IA (original type I). Population decreases during the fishing season. Fishing mortality is proportional to population present at any instant of the season. Natural mortality and recruitment are absent.

IB. Like IA, but with natural mortality present, and occurring at a rate proportional to population.

IIA. Population is steady, the number of recruits being equal to the number of deaths annually, and both are distributed uniformly throughout the season.

IIB. Population may either increase or decrease. Recruitment is at an even absolute (linear) rate through the season. Natural and fishing mortality occur at a rate proportional to population present at any moment.

Definitions and Relationships

Instantaneous and Seasonal Mortality Rates.—In discussing mortality in a fish population, two principal measures can be used. The *seasonal mortality rate*, represented by a, is the fraction of the fish present at the start of a season which die in the course of the season. Corresponding to this there is an *instantaneous mortality rate*, represented by i, which is proportional to the fraction of the population killed during any short interval of time. A thousandth of the season is usually a sufficiently short interval to give an instantaneous rate correct to 3 figures. It can be found from the expression:

$$(1 - a) = \left(1 - \frac{i}{1000}\right)^{1000} \tag{1}$$

where $\frac{i}{1000}$ is the fraction of the population on hand during each thousandth of the season, which is killed during that interval. The fraction i itself is the instantaneous rate of mortality proper, as expressed on a seasonal basis. Because of the apparent contradiction in terms here, the idea of an instantaneous rate is perhaps more easily grasped by considering some small part of the season. This is particularly true when i is greater than unity, so that the instantaneous mortality rate is more than 100 per cent. Expression (1) above could be used to find i from a, or vice versa, using a 7-place table of logarithms.

The accurate limiting form of (1) is:

$$(1 - a) = \left(1 - \frac{i}{n}\right)^{n} \quad (n \to \infty) \tag{2}$$

This is equivalent to $(1 - a) = e^{-i}$, so that:

$$a = 1 - e^{-i} \qquad (3)$$

An easier way, therefore, to convert from a to i, is by consulting a table of the exponential function e^{-i}. For convenience, pairs of values of i and a are presented herewith at sufficiently close intervals that linear interpolation will give the value of a correct to 3 places (Table I).

TABLE I. CORRESPONDING VALUES OF THE INSTANTANEOUS (i) AND SEASONAL (a) MORTALITY RATE. $a = 1 - e^{-i}$.

i	a	i	a	i	a	i	a	i	a	i	a
0.00	.0000	0.25	.2212	0.50	.3935	1.00	.6321	1.50	.7769	3.0	.9502
0.01	.0100	0.26	.2289	0.52	.4055	1.02	.6394	1.55	.7878	3.1	.9550
0.02	.0198	0.27	.2366	0.54	.4173	1.04	.6465	1.60	.7981	3.2	.9592
0.03	.0296	0.28	.2442	0.56	.4288	1.06	.6535	1.65	.8080	3.3	.9631
0.04	.0392	0.29	.2517	0.58	.4401	1.08	.6604	1.70	.8173	3.4	.9666
0.05	.0488	0.30	.2592	0.60	.4512	1.10	.6671	1.75	.8262	3.5	.9698
0.06	.0582	0.31	.2666	0.62	.4621	1.12	.6737	1.80	.8347	3.6	.9727
0.07	.0676	0.32	.2739	0.64	.4727	1.14	.6802	1.85	.8428	3.7	.9753
0.08	.0769	0.33	.2811	0.66	.4831	1.16	.6865	1.90	.8504	3.8	.9776
0.09	.0861	0.34	.2882	0.68	.4934	1.18	.6927	1.95	.8577	3.9	.9798
0.10	.0952	0.35	.2953	0.70	.5034	1.20	.6988	2.00	.8647	4.0	.9817
0.11	.1042	0.36	.3023	0.72	.5132	1.22	.7048	2.05	.8713	4.2	.9850
0.12	.1131	0.37	.3093	0.74	.5229	1.24	.7106	2.10	.8775	4.4	.9877
0.13	.1219	0.38	.3161	0.76	.5323	1.26	.7163	2.15	.8835	4.6	.9899
0.14	.1306	0.39	.3229	0.78	.5416	1.28	.7220	2.20	.8892	4.8	.9918
0.15	.1393	0.40	.3297	0.80	.5507	1.30	.7275	2.25	.8946	5.0	.9933
0.16	.1479	0.41	.3363	0.82	.5596	1.32	.7329	2.30	.8997	5.5	.9959
0.17	.1563	0.42	.3430	0.84	.5683	1.34	.7382	2.35	.9046	6.0	.9975
0.18	.1647	0.43	.3495	0.86	.5768	1.36	.7433	2.40	.9093	6.5	.9985
0.19	.1730	0.44	.3560	0.88	.5852	1.38	.7484	2.45	.9137	7.0	.9991
0.20	.1813	0.45	.3624	0.90	.5934	1.40	.7534	2.5	.9179	7.5	.9994
0.21	.1894	0.46	.3687	0.92	.6015	1.42	.7583	2.6	.9257	8.0	.9997
0.22	.1975	0.47	.3750	0.94	.6094	1.44	.7631	2.7	.9328	8.5	.9998
0.23	.2055	0.48	.3812	0.96	.6171	1.46	.7678	2.8	.9392	9.0	.9999
0.24	.2134	0.49	.3874	0.98	.6247	1.48	.7724	2.9	.9450	10.0	1.0000

a	i	a	i	a	i	a	i
0.00	.0000	0.25	.2877	0.50	.6931	0.75	1.3863
0.05	.0513	0.30	.3567	0.55	.7985	0.80	1.6094
0.10	.1054	0.35	.4308	0.60	.9163	0.85	1.8971
0.15	.1625	0.40	.5108	0.65	1.0498	0.90	2.3026
0.20	.2231	0.45	.5978	0.70	1.2040	0.95	2.9957

This concept of corresponding pairs of rates, applying respectively to the decrease at an "instant" of time, and that during some finite period of time, has of course uncounted applications in all branches of natural science. Its use in this connection dates back at least to Baranoff,[2] who distinguished the *coefficient of decrease*, represented by k, and the *yearly decrease*, represented by ϕ.

While the instantaneous mortality rate is in a way more abstract than the seasonal one, it has characteristics which make it very useful in fisheries problems. Indeed it has best claim to be called the *real* mortality rate, because it represents the actual pressure which the population is subject to, at

2 Baranoff's Figure 5, giving the relation between k (*koeffitsient ubyli*) and ϕ (*godichnaia ubyl*) can be used for the same purpose as our Table I. His k-values are however only 1/5 of our i, because they correspond to a centimeter increase in length in a fish which grows 5 centimeters a year: i.e. the instantaneous mortality rate is expressed on the basis of only 1/5 of the year.

any and at every instant. From this there follow two important corollaries. 1. *If two or more causes of mortality act on a population, and their instantaneous rates be known, the combined instantaneous rate can be found by ordinary addition.* For example, if a population is subject to a seine fishery taking 1 per cent per day of its numbers, and a troll fishery taking 2 per cent, while $\frac{1}{2}$ per cent die from other causes, then the total mortality is $3\frac{1}{2}$ per cent per day—assuming that for practical purposes a day is equivalent to an "instant." The simple additive nature of instantaneous rates makes it very easy to combine them or to segregate them into component parts. 2. *The total deaths during a season will be the product of the instantaneous mortality rate and the average population present.* Suppose that during 1/1000 of a season $i/1000$ of the population then present is killed. The total deaths will be the sum of those killed in each such "instant," so if the population remains unchanged during the season, the total mortality will be i times that population. If, however, population changes, the total deaths will be the sum of $i/1000$ times the population present during each thousandth of the season, which is the same as i times the average population present. As we shall see, an easy way to estimate the total seasonal mortality will be in fact to estimate first the average population present.

Graham (1935, 1938) has made much use of the instantaneous or "logarithmic" mortality rates. He assigns the special term *rate of fishing* to the instantaneous rate of fishing mortality, and gives a lucid exposition of the two relationships just discussed.

POPULATIONS OF TYPE IA.—If mortality in a population is entirely due to fishing, the number of fish dying each instant will vary directly as the amount of gear in use, provided the units of gear work independently. This is the same as saying, with Baranoff, that the *instantaneous* mortality rate varies with the "mechanical intensity" of fishing, as represented by the amount of gear in use. The same cannot be said for the *seasonal* mortality rate, even supposing the amount of gear to remain constant throughout the season; for an increase in gear, from one year to the next, will, by making the population decrease faster, have a less than proportional effect upon the seasonal mortality rate. This is the essence of the relationship between fishing effort (f) and seasonal mortality rate (m) in successive years:

$$\frac{f_2}{f_1} = \frac{\log(1 - m_2)}{\log(1 - m_1)}, \tag{4}$$

which was developed by the writer (1940: 44–49) with what now seems an unnecessary amount of elaboration. Since in type IA populations the fishing mortality rate m is the same as the total mortality rate a, then given Table I, it will be easier to use this relationship in the form which Baraanoff originally proposed:

$$\frac{f_2}{f_1} = \frac{p_2}{p_1}, \tag{5}$$

where p represents the instantaneous rate of decrease corresponding to seasonal rate m.

In developing this relationship the writer had in mind a mobile fish population, which, if locally depleted by a unit of fishing gear, would very quickly

reinvade the area and make good the loss, leaving the generally reduced level of the population as the only permanent effect. (It is understood of course that gear should be widely distributed, so that no very long migrations would be necessary.) With an extremely mobile population, equation (4) would be true even if the gear were unmovable, and fished at exactly the same stations throughout the whole season.

Anticipating the application of (4) and (5) to other types of fisheries, it is interesting to notice that Baranoff (p. 96) arrived at the same result by a different route. Having in mind the trawl fishery of the North Sea, he pointed out that the trawlers would, in part, haul over grounds already fished by other boats, and to an increasing extent, the greater was the total number of trawls in use. Hence, even though the fish were absolutely stationary, the effect of an increase in trawling would be described by formula (4) above, provided trawling is done at random.

Most fisheries will present some combination of the above two situations, and it might seem that the combination would behave differently from either component. Actually this is not the case: for migration, in so far as it tends to fill up a locally fished-out area by lowering the general level of abundance, will make the catch on that area closer to average, the next time gear operates there. The two situations therefore compensate each other; their combined effect will be the same as that of either one operating singly. We can go farther, and say that there will probably be situations where the movements of gear are not sufficiently random, and movements of the fish are not sufficiently pronounced, for either alone to satisfy the conditions for equation (4), but the combination will have the required characteristics.

For popular fisheries, either sport or commercial, there will usually be little doubt that fishing effort is reasonably thoroughly distributed over the accessible area throughout the season, and that therefore decrease will approximate closely to the type considered here, even when the fish wander little. To grasp this fact, one has only to picture the well-worn paths which line an accessible trout stream; or the flotillas of anchored rowboats, bristling with bamboo poles, which cover the Indiana lakes on summer mornings; or a favorite bank in the North Sea, where a trawler may be able to see more than a hundred of his competitors at one and the same time.

POPULATIONS OF TYPE IB.—In type IB populations there are, in addition to mortality from fishing, deaths from other causes collectively designated as "natural." The first thing to notice in this situation, as compared with IA, is that there is an important difference in the meaning to be attached to m, the seasonal rate of fishing mortality. Instead of being a real quantity—the seasonal expectation of death of an individual fish—m becomes hypothetical: it is the fraction of the original population which would have been killed by fishing, if no natural mortality were present. Schaeffer (1943) has shown that equation (4) above is valid for type IB populations, when natural mortality occurs at a rate proportional to population present. But while it is natural to imagine that natural mortality will occur in this way, it is not at all essential that this be so. Once m loses touch with reality, and we define it (quite unavoidably) as the number of fish which *would be* killed, *if* no natural mortality occurred, then it can make no difference to equation (4)

whether natural mortality is proportional to population, or whether it is concentrated at the beginning, the middle, or the end of the fishing season.

For the purpose of combining fishing and natural mortality in type IB populations, it is of course easiest to make the assumption that natural mortality, like fishing mortality, is proportional to population present at any instant. If so, the instantaneous rate of natural mortality q can be added arithmetically to the instantaneous rate of fishing mortality p, to give the total rate i, as explained earlier. This is of course impossible with the corresponding seasonal rates, which can however be combined by converting to the instantaneous rates, adding, and converting back. Another expression for combining any number of seasonal rates, which amounts to the same thing, is:

$$\log(1 - a) = \log(1 - m) + \log(1 - n) + \ldots \tag{6}$$

where m, n, etc. are seasonal rates, and a is their combined effect. If only two such rates are involved, (6) reduces to:

$$a = m + n - mn$$

Though any seasonal rate of mortality is unreal when other sources of mortality exist along with it, there is, granting the assumption of the last paragraph, a real concept which can be used here, namely the (seasonal) *expectation of death* of an individual fish from a given cause. Such expectations of death will obviously be proportional to the corresponding *instantaneous* mortality rates, but their arithmetic sum must equal the total seasonal mortality rate. If μ, ν, etc. be expectations of death corresponding to instantaneous mortality rates p, q, etc.; and if i and a be the total instantaneous and seasonal mortality rates, respectively, then:

$$\mu = \frac{pa}{p + q + \ldots} = \frac{pa}{i}; \quad \nu = \frac{qa}{p + q + \ldots} = \frac{qa}{i}; \text{ etc.}; \tag{7}$$

or,

$$\frac{i}{a} = \frac{p}{\mu} = \frac{q}{\nu} = \ldots. \tag{8}$$

The kind of calculation, too, is found in Baranoff (p. 95); but in my earlier paper (1940: 60), and in the paper by Thompson and Bell (1934: 29, 35), it has erroneously been assumed that expectations of death would be proportional to the corresponding *seasonal* mortality rates. Some results of this mistake are discussed in the second part of this paper.

This expectation of death from fishing has a peculiar interest and importance, and was given in 1940 the special name *rate of exploitation*. This is the statistic which will usually be obtained from recaptures of marked or tagged fish (under favorable conditions, that is), and consequently will often be the most important piece of experimental information available, from which other statistics of a fish population are to be computed.

RECRUITMENT.—Before discussing fisheries involving recruitment, it will be well to indicate exactly what is meant by that process. Suppose a fish population to be divided into two groups, on the basis of whether each fish is or is not large enough to meet the legal limit of size to be caught. (When minimum size is governed merely by the kind of fishing gear in use, the dividing line is more diffuse, but no less real.) Those fish which, on any day,

pass the dividing line between the two groups, are new recruits to the "legal," "commercial" or "catchable" population.

It is obvious that whenever recruitment takes place during the time fishing is in progress, some of the current season's recruits will turn up in the catch. Consequently in type II fisheries catch will not, in general, be any simple function of the population present at the start of the fishing season, as it was in type I fisheries. We must therefore examine this relationship in different situations.

Before doing so, it is important to observe that recruitment makes no difference to the fact that the instantaneous fishing mortality rate will vary as the gear in use (formula 5 above), since this relationship does not in any way depend on the level of population within the season, or on the actual size of the catch. Similarly, on the "unreal" definition of seasonal fishing mortality rate m, it is obvious that formula (4) will apply too to all fisheries involving recruitment, of whatever type, and not merely (as Schaeffer seems to imply) to those in which recruitment varies as population. The symbol m now represents the fraction which the catch would have been of the original population, if both recruitment and non-fishing mortality had been absent; or alternatively, the fraction of the original population which would have been killed, if non-fishing mortality had been absent.

Recruitment which occurs at a rate proportional to population present is the logical complement of the type of mortality which we have been considering, so it may detain us for a moment. Such recruitment can be treated similarly to mortality. There will be an instantaneous rate of recruitment h, of opposite sign to the mortality rates, and a corresponding seasonal rate of recruitment d, connected by the relationship:

$$(1 + d) = \left(1 + \frac{h}{n}\right)^n \quad (n \to \infty)$$

or,

$$d = e^h - 1 \tag{9}$$

The instantaneous rate of recruitment can be subtracted from the instantaneous mortality rate to give a net rate of increase or decrease of the population, represented by:

$$h - (p + q) = h - i = g$$

Now if g is positive, a unit population will increase in unit time (one fishing season) to e^g, and its average abundance[3] will be:

$$\int_0^1 e^{gt} dt = \frac{e^g - 1}{g} \tag{10}$$

Since the total mortality will be i times the average population, the total mortality during a season will be:

$$\frac{i(e^g - 1)}{g}, \tag{11}$$

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[3] Finding average population by integration is based on the following principle: If a curve be plotted of population against time (t), then integration over unit time ($t = 0$ to $t = 1$) gives the area bounded by the curve, the two axes, and the ordinate of $t = 1$. The mean height of the curve (= the average population) is found by dividing this area by the length of time on the t-axis. Since this length of time is unity, the area itself is numerically equal to the average population. It would be just as easy to find average population for say 3 years, by integrating from $t = 0$ to $t = 3$, the area obtained being divided by 3 to give the average population. Similarly, the average population during the nth year could be found, by integrating from $t = n - 1$ to $t = n$.

and the catch will be $\dfrac{p}{i}$ times that—all expressed as a fraction of the initial population. If however g is negative the population will decrease in unit time to e^{-g}, and its mean abundance will be

$$\int_0^1 e^{-gt}dt = \frac{1-e^{-g}}{g}\,,\tag{12}$$

so that total mortality is:

$$\frac{i(1-e^{-g})}{g}.\tag{13}$$

At the moment, it is not clear that these expressions are likely to be of any great value in fisheries work. For to postulate that recruitment is proportional to population present, imposes a serious restriction upon the usefulness of the resulting calculations, whenever population is changing. It is eminently reasonable to represent *mortality* in such a way, though it will certainly not be universally true even there. But to expect recruitment to vary as population does within a fishing season is obviously very unreasonable, because the rate of recruitment depends on the number, size and rate of growth of the sub-legal fish of the population, and is independent of the number of legal fish already vulnerable to fishing. Another point which might be overlooked is that to postulate a uniform *rate* of recruitment of this type, from year to year, will mean that the actual number of fish recruited will vary from year to year, if population changes. Indeed, any value of g whatever, other than 0, describes an unstable population, which will either increase or decrease indefinitely.

POPULATIONS OF TYPE IIA.—Of the numerous ways in which recruitment can take place, that in which the same absolute number of recruits enters the fishery on each day of the fishery season seems to be the one most likely to occur, and most likely to represent the average situation. However, there is found sometimes, at least in reasonable facsimile, a situation where recruitment is both proportional to population and also takes place at a uniform absolute daily rate. This is the situation designated as type IIA. It occurs when recruitment equals mortality, and both have been stabilized over a period of years, so that population remains unchanged both within each fishing season and also from season to season. Since the fishing season is assumed to extend over the whole year, the word "year" will usually be substituted for "season" in discussing type II fisheries. It would not matter, of course, if fishing were interrupted for part of the year, provided natural mortality and recruitment were also largely suspended—as they might be by freezing temperatures, for example.

All of the rules and formulae given above for type IB fisheries will, within limits, apply also to type IIA. They apply, that is, to legal fish, which are already vulnerable to fishing at any given instant—it is easiest to think of them as applying to the fish present at the beginning of a fishing season. The difference between IB and IIA populations is perhaps shown best by the meaning which attaches to a, the total mortality rate. In IB, this represents both (a) the ratio *total deaths : initial population*, and also (b) the seasonal

expectation of death of any individual fish. In IIA populations, a is still the
expectation of death of fish present at the start of the fishing season, but it no
longer represents the ratio (a), because a considerable number of deaths will
occur among the group being currently recruited. The ratio *total deaths* :
steady population can readily be found however. Corresponding to yearly
(seasonal) mortality rate a is instantaneous rate i. Since total population, by
definition, remains unchanged, exactly the same number of fish will die in
each and every "instant" of the year. That is, during each small interval, or

nth, of the year, $\dfrac{i}{n}$ of the fish present die. The number of fish present

(call it N) does not vary, however, so the total mortality is $\dfrac{Ni}{n} + \dfrac{Ni}{n} + \ldots$

to n terms, or Ni in all (cf. Baranoff: 91). This makes it possible to classify
the annual deaths in a type IIA fishery, as follows:

Total mortality (hence also the annual number of recruits) ....Ni
Mortality among fish present at the start of the year ....Na $\Big\}$ (14)
Mortality among fish recruited during the year ....$N(i$ - $a)$

The corresponding values, expressed as fractions of a unit number of an-

nual recruits, are $\dfrac{1}{Ni}$ times (14), or:

Total mortality 1
Mortality among fish present at the start of the year ....$\dfrac{a}{i}$ $\Bigg\}$ (15)
Mortality among fish recruited during the year ....$\dfrac{i\text{ - }a}{i}$

The writer's earlier treatment of this point (1940: 61) used $a/2$ in place of
the last line of (15). That is, it was assumed that if recruitment is at a
steady rate through the year, the average mortality rate among recruits is
exactly half of that among older fish. This is a fair approximation when a
is small, but when a exceeds 0.5 the difference becomes considerable.

It is possible to push the analysis farther, and determine the actual
abundance of any year-class of recruits at any time after it first starts to
appear. Considering a balanced population of N fish, the N which are present
at the start of a year will decrease in numbers according to the formula:
$$Ne^{-it} \tag{16}$$
t being measured in years. Since population remains constant, the survivors
of recruits of the current year will be, at any time:
$$N - Ne^{-it} = N(1 - e^{-it}) \tag{17}$$
At the end of their year of recruitment ($t = 1$), the recruits number:
$$N(1 - e^{-i}) = Na, \tag{18}$$
since $a = e^{-i}$. Thereafter they decrease according to expression (16), so
that at the end of the second year they number:
$$Nae^{-i} = Na(1 - a). \tag{19}$$
After the lapse of n years they number:
$$Na(1 - a)^{n-1} \tag{20}$$
The whole population of N fish is therefore built up of the successive year-
classes represented by (18), (19), etc., as follows:
$$Na + Na(1 - a) + Na(1 - a)^2 + \ldots = N. \tag{21}$$

This is a converging geometric series whose sum is equal to the total population, N.

By a similar analysis, a year's mortality, Ni, in a balanced population of N individuals, can be shown to be composed of recruits and older year-classes in the numbers given by successive terms of:

$$N(i - a) + Na^2 + Na^2(1 - a) + Na^2(1 - a)^2 + \ldots = Ni \qquad (22)$$

Each term of this expression is a times the preceding term in (21), the first term being taken from (14).

It will be useful to have these formulae too expressed in terms of the number of annual recruits. Since, from (14), the recruits number i times the population, the successive year-classes in the population, as fractions of a unit annual number of recruits, are $\dfrac{1}{Ni}$ times (21), or:

$$\frac{a}{i} + \frac{a(1 - a)}{i} + \frac{a(1 - a)^2}{i} + \ldots = \frac{1}{i} \qquad (23)$$

Similarly, the mortality among successive year-classes is $\dfrac{1}{Ni}$ times (22), or:

$$\frac{i - a}{i} + \frac{a^2}{i} + \frac{a^2(1 - a)}{i} + \frac{a^2(1 - a)^2}{i} + \ldots = 1 \qquad (24)$$

FISHERIES OF TYPE IIB.—Consider a population which has balanced itself at a density of M individuals, under the influence of an instantaneous mortality rate j and the corresponding annual rate b, and a uniform rate of recruitment. Suddenly, between two years, the mortality changes to instantaneous rate i and annual rate a, while the annual number of recruits remains the same. We wish to trace the change in abundance of the population during the period of years while adjustment to the new mortality rate is taking place. If the new rate i remains in effect over a period of years, eventually the population will reach a new stable level; call this N. Then combining (16) and (17), the population at any time t during the interregnum would be represented by:

$$Me^{-it} + N(1 - e^{-it}) = N + (M - N)e^{-it}$$
$$= N + (M - N)(1 - a)^t, \qquad (25)$$

t being expressed in years, measured from the time the mortality rate changed to i.

If desired, this population can be broken up into separate year-classes in a manner similar to expression (23). Consider a year-class which has lived for m years (including the year of recruitment) under the old mortality rate b, and for n years under the new rate a. From (15), during the first year $\dfrac{j - b}{j}$ times the number of recruits are killed, and hence $1 - \dfrac{j - b}{j} = \dfrac{b}{j}$ survive. During the second year b times $\dfrac{b}{j}$ are killed, and $\dfrac{b}{j} - \dfrac{b^2}{j} = \dfrac{b}{j}(1 - b)$ survive. At the end of m years $\dfrac{b}{j}(1 - b)^{m-1}$ survive. During the first year of the new mortality rate a, a times $\dfrac{b}{j}(1 - b)^{m-1}$ are killed,

and $\frac{b}{j}(1 - b)^{m-1}(1 - a)$ survive. After the lapse of the total period of $m + n$ years, therefore, the survivors number:

$$\frac{b}{j}(1 - b)^{m-1}(1 - a)^n, \tag{26}$$

expressed as a fraction of the original number recruited. This expression is valid only when $m > 0$; otherwise the nth term of (23) is applicable. From (23) and (26), we can write down the whole series of year-classes present at the start of any given year. For example, two years after the change in mortality rate, the abundance of successive year-classes would be:

$$\frac{a}{i} + \frac{a}{i}(1 - a) + \frac{b}{j}(1 - a)^2 + \frac{b}{j}(1 - a)^2(1 - b)$$

$$+ \frac{b}{j}(1 - a)^2(1 - b)^2 + \dots . \tag{27}$$

each as a fraction of the steady number of recruits.

To find the total mortality of the whole population in any year after the change in mortality rate, the average population present during the nth year can first be calculated, by integrating (25) over a year's time and substituting $1 - a$ for its equivalent e^{-i} after the integration is performed:

$$N + (M - N)\int_{n-1}^{n} e^{-it}dt = N + \left(\frac{M - N}{i}\right)(1 - a)^{n-1} - (1 - a)^n$$

$$= N + \frac{a}{i}(1 - a)^{n-1}(M - N) \tag{28}$$

The population mortality in the nth year will be i times this, or:

$$Ni + a(1 - a)^{n-1}(M - N) \tag{29}$$

Notice that Ni, in (29), is the annual number of recruits, the remainder of the expression being positive when population is decreasing, and negative when it is increasing. The catch in any year is of course $\frac{p}{i}$ times (29), or p times (28). In substituting numerical values in (29) it is convenient to bear in mind that, as is implied in (14), for any given rate of recruitment the balanced population is inversely proportional to the instantaneous mortality rate; i.e.:

$$M j = N i = \text{the annual number of recruits.} \tag{30}$$

Expressions (28) and (29) can also be used in a situation where the population is not balanced at the beginning, that is, where M has some arbitrary value; in which case, of course, (30) will not apply.

We will not break down the mortality during a period of population change into its component year-classes, though it can be done very readily from expressions like (27), by multiplying each term by the current seasonal mortality rate, and adding the mortality among recruits.

WEIGHT OF CATCH.—In the foregoing we have been concerned solely with the *number* of fish in a population, or in a catch. The yield of a fishery is, however, commonly computed in terms of the *weight* of fish caught, and this introduces an additional factor into the calculations.

Consider first a IA fishery, which attacks, each year, a single age-class of

an anadromous fish, for a relatively short time along its migration route. Here the amount of fishing should not directly affect the average weight of the fish either during the current year or in future years. If, however, some of the fish in the population survive more than one season, then of course intensity of fishing, this year, may affect the average weight of future years' fish, by regulating the number of old fish present. In this latter event, the expected change in average weight, resulting from a change in average age of the fish in the stock in future years, must be considered in estimating the probable yield that would follow a change in fishing effort.

It was mentioned earlier that the existence of a type IB fishery must be an exceptional event, so we will not consider them in detail, in this connection. However, in IB fisheries, the level of fishing effort will affect the average weight of fish captured during the *current* season, assuming that the fish grow throughout the fishing season. The more rapidly their numbers are reduced during a season, the less should be the average weight of the fish taken. Thompson and Bell (1934: 31, footnote) in estimating the yield in pounds from a type IB fishery, have avoided this complication by assuming that the average weight of fish caught from each year-class will be the same regardless of the mortality rate. This is tantamount to postulating that the growth of their fish, like the recruitment, all occurs during a time of year other than that during which all of the mortality occurs.

In type II fisheries the same difficulty appears, if an attempt is made to calculate the weight of each year-class of recruits separately. There is also another one: supposing the average weight of fish of the successive year-classes, after the first, can be represented by some mathematical expression, then we should not expect the average weight of a year-class of recruits to fit into the same series. For whereas increasing numbers of recruits are taken during the latter part of the fishing season, relatively more older fish are taken near the start. For both these reasons, the computation of weight in a type IIB fishery in the writer's earlier paper (1940: Table IV) is, to say the least, unrealistic.

It would be possible to compute the average weight of recruits and of successive older groups for any given mortality rate, but the problem of finding total weight of catch in type II fisheries can usually be solved more simply. For this purpose it is necessary that rate of growth should conform reasonably well to a reasonably simple mathematical formulation, over the range of important year-classes of fish. Baranoff (p. 105) computed the yield in balanced populations (type IIA) when the fish increase in length at a uniform (linear) rate from year to year, and weight varies as the cube of length. He cited evidence that many fishes, including the North Sea plaice, did in fact grow in this manner, over the commercially-important size range.

We shall deal here only with what is, for our purposes, a much simpler type of growth, namely exponential increase in average weight, such as Dunlop demonstrated in a Pacific halibut population (Thompson and Bell: 30). Such increase is equivalent to a recruitment whose rate is proportional to weight of population present, superimposed upon the uniform rate of recruitment we have been considering. Considering the year-class as a whole, its instantaneous rate of growth k can be subtracted from the instantaneous mortality rate to give the net instantaneous rate of decrease in weight as

$i - k$, and a set of concepts can be developed, exactly analogous to those used in discussing population abundance. For example if a total weight S of fish is present at the start of a year, those fish will decrease in weight in a manner similar to (16); namely, according to the expression:

$$Se^{-(i-k)t} \tag{31}$$

Naturally k cannot exceed i, or the net weight of a year-class would continually increase.[4]

Of more direct importance is an analogy with the first line of (14). The number of fish N in a balanced population equals the number of recruits divided by i; similarly the weight of the fish, S, in a balanced population equals the weight of recruits, W, divided by $i - k$; i.e.:

$$S = \frac{W}{i - k} \tag{32}$$

However, mortality affects the fish as individuals, whether they grow or not, quite independently of their weight. Consequently the number of fish killed annually will still be i times the steady population, as in expression (14). Since by hypothesis all ages and sizes of fish suffer equally, the annual mortality in terms of weight will be i times the steady weight of the population, viz.:

$$\frac{Wi}{i - k} \tag{33}$$

This expression differs from (14) in that the total yearly *weight* of fish dying exceeds the total weight of the recruits, whereas the *number* dying annually equals the number of recruits. The ratio of initial weight of recruits to weight of annual deaths is W to $\dfrac{Wi}{i - k}$, or $(i - k)$ to i, which merely reflects the obvious fact that the faster the fish grow the bigger they will have become, on the average, before death occurs.

Since the catch is $\dfrac{p}{i}$ times the total mortality, the expression for the yearly weight of fish caught is $\dfrac{p}{i}$ times (33), or:

$$\frac{Wp}{i - k} \tag{34}$$

If (34) be written in the form $\dfrac{Wp}{p + q - k}$, it is evident that an increase in p will increase the catch if $q - k$ is positive, but will decrease it if $q - k$ is negative. Since p varies as fishing effort (equation 5), it follows that increased fishing results in increased catch when the instantaneous rate of natural mortality exceeds the rate of growth; but if this is not so, increased fishing will reduce the total catch of fish. These results apply, of course, only to balanced populations, since increase in fishing will always produce at least a temporary increase in catch.

When population numbers are changing following a change in total mortality rate, the weight of the population can be found by making suitable

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[4] This is not to say that in nature a year-class might not increase in weight for some years, to decrease and die out later. Indeed, considering the whole life of the fish right from hatching, this obviously must happen. It could be brought about by variation in either mortality rate, or in rate of growth, with the age of the fish. No discussion of the weight of a commercial population in which these factors are variable can be given here, but obviously it may be an extremely practical question.

modifications of the earlier argument. Consider a population balanced in
respect to both numbers and weight, under the influence of instantaneous
mortality rate j and growth rate k, and a uniform number of recruits weigh-
ing W kilograms each year. From (32), the steady weight of the population
will be $\dfrac{W}{j-k}$; call this R. Among these various factors, let the mortality
rate, and it alone, suddenly change from j to i. The weight of the population
immediately begins to change, and after a period of years it is stabilized at
$\dfrac{W}{i-k} = S$. The weight of the population at any time during the period
of change is, by analogy with (25):

$$S + (R - S)e^{-(i-k)t} \tag{35}$$

and its average weight during the nth year after the change is found, by pro-
cedure similar to that used in developing (28), to be:

$$S + \frac{z}{i-k}\ (1-z)^{n-1}\ (R-S), \tag{36}$$

where $z = 1 - e^{-(i-k)}$. The total weight of fish dying in any year is of course
i times (36), and the weight of the catch is p times (36).

Similar computations could be made if k, instead of j, were to change, or
if (as is more likely) both were to change simultaneously.

As a final exercise, we can apply a method of Baranoff's (p. 94) for esti-
mating the total mortality and survival rate in a population, to the situation
where growth is exponential. If the individual fish being recruited weigh w
kilograms each, and during a year there are B of them, their total weight
is $W = Bw$ kilograms. The number of fish in the steady population is, from
(30), $N = \dfrac{B}{i}$, while the total weight of the steady population is, from (32),
$\dfrac{Bw}{i-k}$. The average weight of a fish in the commercial population is the
quotient of these, or:

$$\frac{wi}{i-k} \tag{37}$$

It follows that if average weight, weight at recruitment or "minimum"
weight (w), and the exponential rate of growth (k) be known, the mortality
rate i can be calculated. Since the minimum weight of fish caught is often
indefinite, it would be best to establish an arbitrary minimum which is at any
rate not too small—i.e. so that all fish larger than the minimum are equally
vulnerable to fishing—and to consider only such fish in estimating average
weight of the fish caught.

In general, this method of determining the mortality rate is probably in-
ferior to the method of comparing the abundance of successive age-classes in
the catch, but it might sometimes be useful where it is impossible to apply the
latter.

CORRECTIONS AND ADDENDA TO PUBLISHED PAPERS

RICKER'S PAPER OF 1940.—An important error in this paper is the as-
sumption that an age-class being recruited at a uniform absolute rate during
a season is subject to exactly half as great a mortality as one present from
the start of the season. This makes the section on page 61 entitled "Age
Composition of a Balanced Population," applicable only in cases where the

total mortality rate a is small. Using the corrected formula in (15) above, it is evident that the suggested limit of catch—200 percent of the (balanced) population—is not real; there is in fact no theoretical limit to the ratio *catch* : *population*. For if fishing is so successful that every recruit is picked up almost as soon as it becomes of legal size, the legal population on hand will remain quite small even though the catch be considerable. Hence catch can be many times as great as population. For example, some heavily-fished trout streams may approximate this condition.

TABLE II

Population and mortality following a change in mortality rate, when recruitment is 1000 fish per year. At the start of the 2nd year the population, previously balanced under the action of total mortality rate $a = 0.4$, is suddenly subjected to a mortality rate $a = 0.8$. The total population at the beginning of each subsequent year is computed from formula (25), the average population during each year from (28), and the total yearly mortality from (29). The catch is calculated as p times the average population, given that the rate of fishing is $p = 0.288$ in the first year and $p = 1.609$ in later years ($m = 0.25$ and 0.75).

YEAR	TOTAL POPULATION	AVERAGE POPULATION	TOTAL MORTALITY	CATCH
	1958			
1st		1958	1000	563
	1958			
2nd		1286	2070	1783
	889			
3rd		754	1213	1045
	674			
4th		648	1043	898
	632			
5th		626	1007	868
	623			
6th		622	1001	862
	621			
7th		621	1000	861
	621			

A corrected version of Table II on page 62 of the 1940 paper can be prepared either by direct computation, or by substituting the appropriate numerical values in expressions such as (27). Given a thousand recruits yearly and a total mortality rate $a = 0.40$, deaths during the year of recruitment would number $\dfrac{1000(i - a)}{i} = \dfrac{1000(0.511 - 0.400)}{0.511} = 217$, in place of the 200 shown at the head of column 3. Similarly, when $a = 0.80$, 503 die during the year of recruitment. After making these initial changes the computation of the rest of the table can be done as before.

The second error in the 1940 paper was the assumption that total deaths in a fishery should be divided between fishing and natural mortality in the ratio of the *seasonal* fishing and natural mortality rates. This misconception was expressed by the two formulae at the middle of page 60. As suggested above, the total deaths should, instead, be divided in the ratio of the corresponding *instantaneous* rates; hence formulae (7) above should be substituted for those on page 60.

Both of the above mistakes were involved in Table III (p. 63), which was meant to show the population and catch at yearly intervals, following an increase in (seasonal) fishing mortality rate from 0.25 to 0.75, natural mor-

tality rate remaining constant at 0.20. The principal purpose of this tabulation was to discover variations in the ratio *catch : average population;* and this ratio appeared (erroneously) to change a little even after the new mortality rate was in effect. But since, almost by definition, we know that mortality is always i times average population, the problem is much simplified. The corresponding values of instantaneous and seasonal rates are as follows:

	SEASONAL RATES			INSTANTANEOUS RATES		
	a	m	n	i	p	q
First year	0.40	0.25	0.20	0.511	0.288	0.223
Later years	0.80	0.75	0.20	1.610	1.385	0.223

Since total mortality is divisible into catch and natural deaths in the ratio $p : q$, the catch in years after the change will be the constant fraction $\dfrac{1.385}{1.610}$ of the total mortality, or 1.385 times the average population, as shown in Table II of this paper. And the gear needed will be constant through these years, and equal to $\dfrac{1.385}{0.288} = 4.81$ times that used in the first year, as shown by equation (5).

The net effect of these corrections is to emphasize more strongly the thesis outlined in the earlier paper: that in type II fisheries, as in type I, a given increase in gear produces a less-than-proportional increase in rate of exploitation of a fishery. Thus, in the example of Table II, the rate of exploitation is $\mu = \dfrac{0.288}{0.511} \times 0.4 = 0.226$, in the first year, and $\mu = \dfrac{1.385}{1.610} \times 0.8 = 0.688$, in the last year: only a 3.04-fold increase, as compared with the 4.81-fold necessary increase in gear. The relationship suggested on page 64 of the 1940 paper still holds good, i.e. that equation (4) above can, by substituting μ for m, be used to calculate *approximately* the effect upon the rate of exploitation of a given change in fishing effort. Thus, in the example of Table II, given $\mu_1 = 0.226$ and $f_2/f_1 = 4.81$, μ_2 is calculated as 0.708, as compared with 0.688 found above—a 3 percent difference. Notice, however, that this close correspondence is a consequence of the logarithmic relationship between f and m; the reverse approximation, that of calculating gear needed to effect a given change in exploitation, involves a much greater percentage error in the result.

It may be asked why the approximation of the last paragraph need be considered when the exact formula (4) is available. The answer lies in the fact mentioned earlier, that the fishing mortality rate, being purely an abstraction in any but IA populations, is not likely to proceed directly from experimental data. The quantity most likely to turn up in actual investigations is the rate of exploitation. A better, though more laborious, way to make such approximate calculations would be to use equation (4) as given, and combine the observed rate of exploitation with whatever rate of natural mortality is considered most probable. Of course, if the data at hand also provide an estimate of the total mortality rate, then a complete solution can be worked out.

Finally, it should be mentioned that the errors of Tables II and III of the 1940 paper are involved in Table IV (p. 65), and in addition the last-mentioned table has an improbable distribution of average weight in successive

age classes, as noted earlier. It is not necessary to recalculate Table IV, however, for the computations involved in it can be taken directly from the analysis given earlier.

The population under consideration is the one whose mortality rates are tabulated four paragraphs above, and there is now the additional information that the fish individually increase in weight by 20 percent per year ($e^k = 1 + 0.20$; hence the instantaneous rate of increase $= k = 0.183$). If the weight of a year's recruits be taken as 1000 kilograms, we find from (32) that the weight of the original balanced population is $R = \dfrac{1000}{0.511 - 0.183} = 3050$ kilograms, and that of the population stabilized under the higher mortality rate is $S = \dfrac{1000}{1.610 - 0.183} = 701$ kilograms. For substituting in (36), we need also $i - k = 1.610 - 0.183 = 1.427$; from which, using Table I, $z = 1 - e^{-1.427} = 0.760$. The average populations and catches in successive years are therefore as follows:

	Ave. Wt. of Pop'n. (Kilograms)	Catch (Kilograms)	Relative Catch Per Unit Gear
Original balanced population	3050	878	1.000
1st year of change	1952	2704	0.640
2nd year of change	1001	1386	0.328
3rd year of change	773	1072	0.254
4th year of change	718	995	0.235
5th year of change	705	977	0.231
New balanced population	701	971	0.230

In the above, the catch is p times the average weight of the population, and the catch per unit gear is based on the 1:4.81 ratio of gears needed in the first as opposed to later years, found from (5).

THOMPSON AND BELL'S PAPER OF 1934.—It was mentioned earlier that Thompson and Bell had used one of the approximations which have just been discussed. This was that they divided total mortality in the ratio of the seasonal natural mortality rate to the seasonal fishing mortality rate, instead of the corresponding instantaneous rates; and the importance of their paper makes it worth while to look into this more closely. On page 29, in the tabulation at the foot, the "proportion taken by the fishery," given as $\dfrac{40}{70}$, should really be $\dfrac{511}{868}$, the ratio of the instantaneous rates—a difference of about 3 percent. On page 35 the same procedure is applied to several different combinations of fishing and natural mortality rate. For example the combination of 60 percent fishing with 10 percent natural mortality rate gives a total mortality of 64 percent, of which $\dfrac{916}{1021}$ or 90 percent is catch—as compared with $\dfrac{6}{7}$, or 86 percent, by the approximate method. The effect of using the revised method in Table II (p. 36) is to make catches somewhat greater than they are shown, especially after the first year. So also are the figures for "catch per skate" in the last line of the table; and the decrease in catch per skate, from the first to later years, is relatively somewhat less than indicated.

Obviously, none of these changes are very large, and none of Thompson and
Bell's general conclusions concerning fish and fisheries are affected by them.
It is only when total mortality is great, and its two components are quite
unequal, that there is serious discrepancy between the two methods.

These conditions are satisfied, however, in parts of Table 8 and Figure
9 (p. 32) of the same paper, and there the error involved becomes consider-
able. To cite the extreme condition, with 100 percent fishing mortality rate
all of the lines on Figure 9 should converge at 4100, the weight of the fish
as they enter the fishery. For, a 100 percent rate of fishing mortality can
mean only one thing: that each fish is caught at the moment it becomes of
legal size, and hence before natural mortality has a chance to operate.
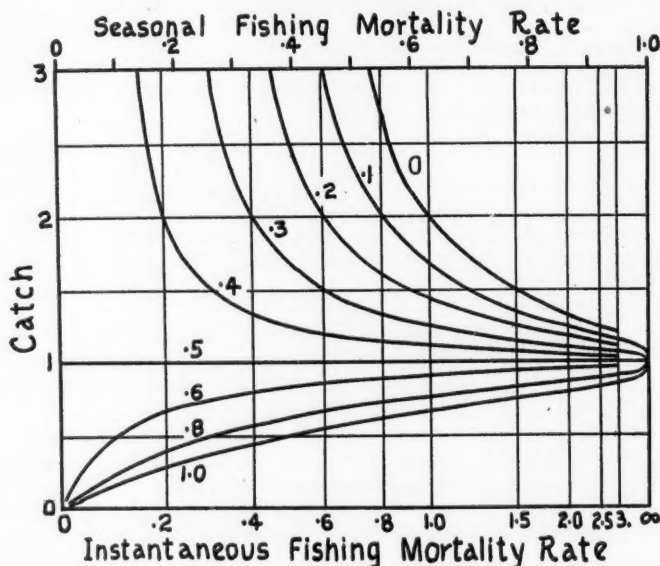
Fig. 1. Annual catch, as a fraction of the initial weight of a year's recruits, for various
combinations of fishing and natural mortality rate, when the instantaneous rate of increase
in weight of an individual fish is 0.5 (i.e. the seasonal increase in weight is 0.65 times the
initial weight). The curved lines represent various instantaneous rates of natural mortal-
ity; for the corresponding seasonal rates, see Table I.

MAXIMUM CATCH.—Calculations of the weight of catch that results from
fisheries stabilized at different levels of natural and fishing mortality have
been made by both Baranoff (Fig. 10) and Thompson and Bell (Fig. 9).
The two figures differ considerably; notably in that Baranoff's shows a
gradual ascent to a maximum of catch, with increasing fishing mortality, and
later a drop—but only when natural mortality rate is between about 0.05
and 0.20. Thompson and Bell's figure shows only the smallest trace of this,
so it will be interesting to discover the reason for the difference.

To eliminate all other sources of difference between Baranoff's figure and

Thompson and Bell's, it will be best to make a similar diagram showing the
catch in a fishery of the type being considered by Baranoff (our type IIA),
but with the fish increasing in weight in the manner observed by Thompson
and Bell, i.e. exponentially. Such a diagram is readily prepared from ex-
pression (34) by varying p and i for a given value of k. Using $k = 0.50$,
which is of the order of the growth rate used by Baranoff, Figure 1 is obtained.
The result is most like Thompson and Bell's figure, though with considerable
differences in detail. When the instantaneous rate of natural mortality equals
the instantaneous rate of growth, the catch is the same regardless of what
fishing effort is used. For higher natural mortality rates, the catch increases
with increasing effort until it approaches the weight of the recruits. For lower
rates, the catch is, theoretically, of unlimited size at the point where $i = k$,
then decreases rapidly, with increasing effort, to levels not far from the orig-
inal weight of the recruits. As the seasonal fishing mortality rate approaches
100 percent ($p \rightarrow \infty$) all the curves converge on unity.

The interesting thing is that there is no trace, in Figure 1, of the maxima
of Baranoff's Figure 10. The difference then lies in the different type of
growth with which he worked: instead of exponential increase in weight, he
used the condition which he believed was characteristic of North Sea plaice,
namely linear increase in length, the weight varying as the cube of length.

DISCUSSION

A general criticism can be urged concerning work of this type, that real
fish populations do not follow mathematical laws, and hence that the conclu-
sions reached in analyses made from them are not germane to actual fisheries
problems. We must grant that, strictly speaking, the first statement is true.
For example, the formulae above frequently include infinite series, whereas
real populations contain only a finite and rather small number of year-classes.
Again, many of the expressions used imply that fish populations are indefi-
nitely divisible, whereas actually they are formed of discrete units, the indi-
vidual fish. We can only emphasize again what is implied through the whole
of the paper, that the agreement of any population to any theoretical picture
is of necessity approximate. The only question at issue will be: is the re-
semblance close enough to make the formulae useful, and this must be
decided for each fishery separately. Where none of the situations developed
in this or earlier papers has sufficient verisimilitude, other types can readily
be developed: the possibilities are unlimited in extent.

A more definite criticism is that in this work, as in that of most earlier
writers, the procedure has been to discover the relationships between fishing
effort, mortality, and size of population, on the assumption that while fishing
effort may change, certain other important characteristics of the fish popula-
tion do not change. These characteristics include (1) the natural mortality
rate, which in addition to being the same from year to year, should affect all
fish of commercially-important sizes equally; (2) the number of annual re-
cruits; (3) the average rate of increase in size of an individual fish. Only
if these things remain substantially unchanged will the conclusions reached
be valid. Baranoff included a discussion of these points at various places
in his paper, and concluded, though on necessarily indirect and in some cases
meager evidence, that the plaice of the North Sea bore a fair resemblance to

the ideal, at least under the conditions of exploitation obtaining in 1905–08. However, at about the same time as Baranoff wrote his paper, C. G. J. Petersen (1922) was accumulating evidence to show that the plaice populations of the Kattegat and neighboring waters had been profoundly changed in at least one of the ways above, since the establishment of the commercial fishery. That is, the rate of growth of the fish had greatly increased, and he suggested that this was a direct result of the greater food supply available to each individual in the smaller population. So effective was this process in the western Baltic Sea that in 1920 plaice 3 to 5 years old were of larger average size than those 10 to 20 years old. Similar though usually less striking changes have been demonstrated in populations of other fishes, but of course they need not occur universally. For example, reduction in one species by intensive fishing might be accompanied by increase in another similar one that is not very vulnerable to fishing, but which would effectively dispose of the available food supply. Changes in natural mortality rate and rate of recruitment are not as easily determined as rate of growth, but *may* be equally dependent on the density or age composition of the population. Consequently in the application of theoretical schemes of this type there will usually remain a considerable margin of uncertainty.

   This uncertainty is greatest when the various rates are applied in circumstances quite different from those which actually exist. The most striking example of this is in the diagrams (Fig. 10 in Baranoff; Fig. 9 in Thompson and Bell; Fig. 1 of this paper) which show the catch resulting from various combinations of natural and fishing mortality rate, on the assumption that these can be varied independently and that neither will affect the rate of growth of the fish. However, it is not likely that the authors of these figures have placed any great confidence in their applicability too far beyond the range of existing conditions; certainly the tremendous catches which are indicated when both natural and fishing mortality rates are small cannot correspond to reality. Baranoff (p. 107) cited the historical fact of the absence of a peak of production of the plaice fishery, at a low level of fishing mortality, as accessory evidence that the natural mortality rate in that population is of the order of 25 percent or more, since his analysis showed that such a peak would occur if the natural mortality rate were less. But it is apparently still an open question whether the fact of fairly steady production of the North Sea plaice fishery during those years was not, as Petersen suggested for Danish waters, determined fundamentally by the food available exercising a controlling effect upon catch by means of its influence on rate of growth.

   It should be observed that Graham (1935: Fig. 1) has made what is in effect an attempt at combining the schemes of Baranoff and Petersen in a mathematical formulation. It is based on the assumption that "the logarithmic rate of natural increase of the stock at a given moment, including rate of reproduction, is directly proportional to the difference between the weight of the stock at that moment and the maximum weight the area will support." As Graham points out, this direct proportion is probably to be considered as merely a first approximation to the real state of affairs. Much work would be needed to test its applicability to a given situation, and the estimation of what maximum weight of stock a given area will support is not always easy.

Nevertheless this approach marks possibly the most interesting recent development in the theory of fishing.

SUMMARY

1. Four types of fish population and fishery have been considered, as described on page 24.
2. The basic concepts and relationships developed by Baranoff for describing mortality in such populations are as follows:

| | SYMBOLS USED BY | | |
	Baranoff	This paper	RELATIONSHIPS
Instantaneous, exponential or logarithmic mortality rates	*		
Total ("Coefficient of decrease")	k	i	
From fishing ("Rate of fishing")	k_2	p	$p + q = i$
From natural causes	k_0	q	
Seasonal mortality rates			
Total	ϕ	a	$a = 1 - e^{-i}$
From fishing	ϕ_2	m	$m = 1 - e^{-p}$
From natural causes	ϕ_0	n	$n = 1 - e^{-q}$
Seasonal expectations of death			$a = m + n - mn$
Total	ϕ	a	$\dfrac{i}{a} = \dfrac{p}{\mu} = \dfrac{q}{\nu}$
From fishing ("Rate of exploitation")	†	μ	
From natural causes	†	ν	$\mu + \nu = a$

* Baranoff's *instantaneous* rates are in terms of 1/5 of the fishing season.
† No special symbol used.

These concepts and relationships are applicable, as they stand, to fisheries of type IB. In types IIA and IIB, they apply to fish already in the adult population at the start of the fishing season. In type IA, $q = n = \nu = 0$, $p = i$, and $m = \mu = a$.
3. Direct proportionality exists between fishing effort and the "rate of fishing" in all four types of populations, provided the distribution of the population, or of the fishing, is random.
4. The number of fish caught yearly from a balanced (IIA) population of N individuals is Np. For an unbalanced population (IIB), the number taken is p times (28).
5. In terms of successive year-classes of recruits, the composition of a IIA population is shown by (21), and of a IIB population by expressions such as (27).
6. If the fish in each year-class in a population tend to increase in weight exponentially, the weight of the yearly catch from a IIA population is described by (34), and from a IIB population by p times (36).
7. The total mortality rate in a population can be estimated from the average weight and rate of growth of its members, using (37).

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A New Species of Carangid Fish from the Northeastern Pacific

By LIONEL A. WALFORD [1] and GEORGE S. MYERS

IN 1938, Mr. Vernon Brock of the Oregon Fish Commission sent us four
specimens of a fish from the Oregon Coast which he believed to belong to
the genus *Decapterus.* About the same time, Dr. W. A. Clemens, then of the
Pacific Biological Station, now of the University of British Columbia, and Dr.
A. L. Pritchard, of the Pacific Biological Station, sent three specimens, appar-
ently of the same species, collected from the west coast of Vancouver Island.
One of these had been recorded by Hart (1935) as *Trachurus symmetricus,*
and this record was copied by Schultz and DeLacy (1936). Another example
secured off British Columbia in 1938 was loaned by Dr. J. R. Dymond of
the Royal Ontario Museum of Zoology.

All these specimens have been examined by us, and appear to represent a
new species which is described below. This is evidently distinct from the

southern California specimen identified and recorded tentatively by Croker (1937) as *Decapterus sanctae-helenae* (Cuvier and Valenciennes), but the same as that noted by H. W. Clark (1938) as *D. scombrinus* (Valenciennes).[2]

Decapterus polyaspis, sp. nov.

HOLOTYPE.—Stanford Natural History Museum No. 14375,[3] a specimen 380 mm. in standard length, from off Reedsport, Oregon.

PARATYPES.—Four specimens in Stanford Natural History Museum, Nos. 14376, 14377, 14378, 14379,[4] ranging from 380 to 410 mm. in standard length; all from the Oregon coast off Reedsport; also one example 510 mm. in standard length, from the west coast of Vancouver Island, No. 10337 from Royal Ontario Museum of Zoölogy, Toronto. In addition, two specimens from the Pacific Biological Station were examined.

DESCRIPTION.—Dorsal VIII-I, 31 to 34, I; (VIII-I, 31, I).[5] Anal II-I, 27-I to 29-I; (II-I-28-I).

Gill rakers on lower limb of first arch, 39 to 41, (41); "gill teeth," i.e., knob-like protuberances on inner side of gill arch, 23–27, (25); keeled scutes, 43 to 52,[6] (43); scales in lateral line, 50–53, (52); pectoral rays, 22 to 24, (23). In standard length, the head is 3.9 to 4.0, (3.88); predorsal length, 2.9 to 3.0, (2.95); pre-anal length 1.8 to 1.9, (1.81); depth, 4.0 to 4.4, (4.36); length of pectoral, 4.2 to 4.5, (4.52); length of ventral, 8.4 to 9.5, (9.50); snout to origin of ventral, 3.1 to 3.5, (3.12); distance from tip of ventral to anus, 8.6 to 12.7, (8.64); length of scuted portion of lateral line, 2.6 to 2.8, (2.71). In head length, the diameter of the eye is 3.7 to 4.1, (4.08); bony interorbital, 3.9 to 6.1, (3.92); length of snout, 3.3 to 3.4, (3.27); opercle, 4.3 to 4.5, (4.26); length of pectoral, 1.1 to 1.2, (1.17).

Teeth in jaws minute; those on tongue in a narrow, club-shaped strip; vomerine patch of teeth anchor-shaped, the anchor portion more or less separated from the shaft; palatine teeth present in a narrow band. Course of lateral line anteriorly runs close to back, slightly past anterior end of soft dorsal, bending sharply and steeply until it reaches the mid-sides.

Color, in spirits, greenish on back and sides, becoming silvery on lower part of sides and white on belly. A black opercular spot, partly on margin of opercle, partly on shoulder girdle.

Named *polyaspis* for the relatively numerous scutes (*poly,* many + *aspis,* shields).

This species appears to be most closely related to *Decapterus russellii* and to *D. maru-adsi*. It differs from both these forms, however, in the much greater number of scutes of the lateral line (32–4$\frac{2}{2}$ in *D. russellii*, and 32–36 in *D. maru-adsi*). Also, while in the latter two species the lateral line curves gradually in a gentle slope in its course from the region over the pectoral fin to mid-sides, in *D. polyaspis* it descends sharply as described above.

Dimensions, proportions and counts of the specimens of *D. polyaspis* measured were as follows:

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2 Since the above was written, this fish has come into some prominence as a commercial species in Oregon.
3 Specimen No. 1 of Table 1.
4 Specimens No. 2, 3, 4 and 5, respectively, of Table 1.
5 Measurements and counts of type indicated in parentheses.
6 We counted as "keeled scutes" all scales in which there was a recognizable keel and spine, however low they might be.

TABLE I

	Actual Measurements						Proportions in Standard Length; or Proportions in Head Length (in bold face)					
	Specimen Number[1]						Specimen Number					
	1[3] 14375	2 14376	3 14377	4 14378	5 14379	6[4]	1	2	3	4	5	6
Total length	430	—	—	—	—	—	—	—	—	—	—	—
Standard length	380	394	380	410	—	510	—	—	—	—	—	—
Head length	98	99	98	103		115	3.88	3.98	3.88	3.98	—	4.43
Snout to tip of pectoral	99	—	98	103	—	125	—	—	—	—	—	—
Length pectoral	84	92	91	91	—	105	4.52[2]	4.28	4.18	4.50	—	4.86
Snout to insertion ventral	122	116	110	124	—	123	3.12	3.40	3.46	3.31	—	4.15
Length ventral	40	46	45	46	—	48	9.50	8.56	8.44	8.91	—	10.63
Predorsal length	129	134	130	137	—	157	2.95	2.94	2.92	2.99	—	3.25
Preanal length	210	217	197	224	—	296	1.81	1.82	1.93	1.83	—	1.72
Depth	87	98	88	94	—	90	4.36	4.02	4.32	4.36	—	5.67
Eye diameter	24	27	27	27	—	22	4.08	3.66	3.63	3.82	—	5.23
Bony interorbital	25	20	20	17	—		3.92	4.95	4.90	6.06	—	
Snout length	30	30	29	31	—		3.27	3.30	3.38	3.32	—	
Length of scuted portion of lateral line	140	150	149	148	—		2.71	2.63	2.55	2.77	—	
Distance from tip of ventral to anus	44	44	30	43	—		8.64	8.96	12.67	9.53	—	
Opercle	23	22	22	23	—		4.26	4.50	4.45	4.48		
Scales in lateral line	52	—	53	—	50							
Keeled scutes	43	46	45	46	45	52						
Dorsal spines	VIII-I	VIII	VIII	VIII-I	VIII-I	VIII-I						
Dorsal rays	31-I	32-I	31-I	31-I	31-I	34-I						
Anal spines	II-I	II-I	II-I	II-I	II-I	II-I						
Anal rays	28-I	29-I	27-I	27-I	28-I	28-I						
Pectoral rays	23	24	24	23	22							
Gill rakers	41	40	40	40	39	40						
Gill teeth	25	26	23	26	27	26						

1 Specimens Nos. 1 to 4 from off Reedsport, Oregon; No. 5 from Masset Inlet, British Columbia; No. 6 from west coast of Vancouver.
2 Same in head: spec., 1.17; spec. 2, 1.07; spec. 3, 1.08; spec. 4, 1.13; spec. 6, 1.10.
3 Type.
4 Specimen No. 10337 from Royal Ontario Museum of Zoölogy, Toronto.

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A Case of Tortuous Orbital Arteries in
Galeorhinus australis Macleay

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ANN E. WHITE

THE tortuous path of the great arteries in the orbit of some sharks (*Zygaena, Carcharias, Alopecias,* etc.) has attracted the attention of many workers in the past. Burne (1923) in his study of the rete-formations and other peculiarities of the vascular system in the shark *Lamna cornubica* has reviewed the literature of the subject. In *Lamna* there is an extreme modification of the vascular system. This takes the form of retia of considerable size in connection with the lateral hypobranchial connective arteries, the lateral cutaneous and cloacal arteries, and the carotid arteries in the orbit. Other related and remarkable features of the vascular system of this shark are the reduction of the aorta and the marked atrophy of the posterior cardinal veins in consequence of the increased flow of blood to and from the somatic and splanchnic areas by way of these unique structures.

Burne describes and discusses a series of gradations in the degree of convolution of the great orbital arteries as shown in *Zygaena,* where both carotids are thrown into a few loose folds in the orbit; in *Carcharias glaucus,* where both vessels are tortuous and the anterior carotid is thrown into many loose coils and folds; and finally an extreme condition as shown in *Alopecias vulpes* where the anterior carotid is thrown into numerous tight coils and the posterior carotid is coiled loosely. In none of these sharks is there ramification or anastomosis of these vessels or their branches in the orbit; but Burne implies rather strongly that the gradations in contortion of the orbital vessels in these sharks form a series leading up to the condition in *Lamna* where both carotids are completely tortuous and ramify to form plexi. The vessels of the plexi anastomose to form the internal carotid and other arteries normally given off as branches directly from the anterior and posterior carotids.

Twenty-five heads of the shark *Galeorhinus australis* Macleay have been dissected in this Department during the course of routine laboratory work, and in one specimen, convolution of the great orbital arteries was present.

The rest showed the normal condition in which the anterior carotid artery leaves the pseudobranchial plexus and without significant change in diameter enters the orbit through a foramen situated in the posterior wall of the orbit between the end of the palato-pterygoid cartilage and the hyomandibula. The anterior carotid then passes over the floor of the orbit giving off the small ophthalmic artery before entering the neurocranium as the internal carotid artery. The posterior carotid artery arises from the first epibranchial loop, enters the orbit through a foramen medial to the posterior end of the palata-pterygoid cartilage and passes along the medial wall of the orbit, giving off the hyoidean epibranchial artery before dividing into the commissural artery and the short external carotid artery. The latter divides into the rostral and maxillary arteries. The condition is similar to that of *Mustelus* and other "typical" sharks.

The occurrence of elongation and convolution of the great orbital vessels in the one specimen is bilateral and shows some tendency to symmetry. The posterior carotids are little affected and follow in general a normal path without obvious diversion, only the maxillary artery in the right orbit being slightly irregular in its course. The anterior carotids are markedly tortuous. Both anterior carotids are slightly enlarged and their walls are flabby in comparison with those of a normal specimen of equivalent size. The vessel on the left proceeds directly for a short distance into the orbit and then takes up its tortuous path. The first few loops are open, but subsequently the vessel is thrown into tight coils which are held close together by fibrous connective tissue. The right anterior carotid also passes directly along the first part of its path in the orbit, and is then similarly thrown into several loose loops before continuing in tight coils across the rest of the orbit. The tendency to symmetry is manifested in the absence of loops or coils on the initial part of the course of each vessel, the looseness of the first few loops and the subsequent tight coils throughout the remainder of the orbit on both sides. This cannot be shown clearly in a sketch from the dorsal aspect. The hyoidean epibrancial, the commissural, the ophthalmic and the internal carotid arteries follow a normal course on both sides.

The condition found in this one specimen resembles more closely the condition described by Burne for *Carcharias glaucus* than that of the other genera dealt with in his paper, with the exception that while the posterior carotid and hyoidean epibranchial are both slightly tortuous in *C. glaucus* such is not the case in the present specimen. The tortuous path of the anterior carotid is more elaborate in this specimen than it is in *Galeus vulgaris* or *Zygaena*, as described by Burne, but exhibits the same general character of these other examples in that the modification is restricted almost entirely to the main trunks and scarcely involves their branches.

It appears to us on considering the literature and the exceptional nature of the present instance where a convoluted condition of the anterior carotids occurs in only one of the 25 specimens which have so far been dissected here, that this condition in *G. australis* is a simple vascular anomaly in the nature of a cirsoid aneurism and accordingly devoid of normal functional significance. The multiple connective tissue adhesions which bind together the coils of these arteries strongly suggest that the condition is an adult and not a congenital development and accordingly similar to that which occurs commonly

on the temporal artery of man. The singular contortion of these vessels in the orbit of an adult *G. vulgaris* described by Burne would appear to be a parallel of the present case.

On this basis it would seem that Burne's series may be more properly divided into three groups: (a) including at least Burne's case of *Galeus* and the present instance for the genus *Galeorhinus,* in which the condition of tortuous orbital arteries is anomalous; (b), *Carcharias* and *Alopecias,* which possess highly contorted orbital arteries but without ramification and plexus formation in the orbit; and (c) including *Lamna* which is at present unique in the possession of tortuous carotids that ramify and subsequently anastomose to form true plexi in the orbits.
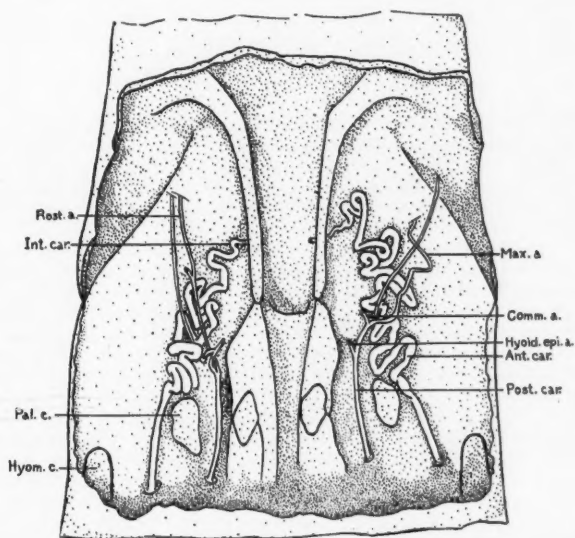

Fig. 1. Dorsal view of a dissection of the contorted great orbital arteries in a specimen of *Galeorhinus australis* Macleay. Ant. car., Anterior carotid artery; Comm. a., Commissural artery; Hyoid. epi. a., Hyoidean epibranchial artery; Hyom. c., Hyomandibular cartilage; Int. car., Internal carotid artery; Max. a., Maxillary artery; Pal. c., Palatopterygoid cartilage; Post. car., Posterior carotid artery; Rost. a., Rostral artery.

Interpreted in this fashion, two factors are apparent. There is the tendency to convolution and the development of convoluted arteries in the orbit in several genera, and there is the condition of plexus formation which exists only in *Lamna.* This suggests that the ultimate interpretation of these peculiarities of the vascular system will require recognition of the convoluted form of the carotids in *Lamna* as secondary to the plexus formation and not contributing to or a lineal precedent of the plexus as is implied by Burne. Contributing evidence in support of this concept is seen in *Lamna* where the vessels supplying and draining the supra-hepatic, sub-renal, and sub-cutaneous rete follow a regular course without contortion.

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Ichthyological Notes

NOTES ON THE SPAWNING OF THE SHOVELHEAD CATFISH, *PILODICTIS OLIVARIS* (RAFINESQUE).—During the fall of 1936 a male shovelhead, or "opelousas" catfish, weighing approximately 60 pounds, was taken in White Rock Lake, near Dallas, Texas, on a trot line. A female of this species was taken in a seine in the spring of 1937 from Wah Hoo Lake, another lake within the city limits of Dallas. She weighed approximately 55 pounds.

These fish were placed in a 3000 gallon tank in the Dallas Aquarium as part of the display. The tank measured 12' x 8' x 4' and was arranged with a gravel and sand bottom varying in depth of 4 inches at the front to 12 inches in the rear. Large flat field stones were arranged to form a ledge across the back section of the tank, so as to allow a resting place on either side for the two fish. Several tree stumps were added to provide a more natural setting for the fish. Shortly after the fish were introduced into the tank the female took up permanent quarters on the left side and the male on the right side of the tank.

In July, 1938, the male moved over to the female's corner; after a courtship of several days the pair spawned. The following morning most of the eggs had been eaten and the balance had been crushed. The tank was in a murky condition as if milk had been mixed with the water. The male returned to his corner and remained until the following June when the same behavior was noted. In August, 1940, the eggs were crushed almost as soon as the laying was completed.

On May 10, 1941, the male started his usual courtship. As this was so much earlier than in previous years little thought was given until some of the more definite spawning activities were noted. As breeding approached the male was often seen with the female, swimming over and beside her, gently rubbing his belly on her back and sides. His barbels apparently had some effect as they were brought into play almost constantly as he rubbed her. There was no apparent change in color during spawning, such as has been observed in many other species of fish. Presently the male came to rest on the bottom with his caudal peduncle and caudal fin encircling the head of the female. This was the same behavior as had been noted in the channel catfish (*Ictalurus lacustris punctatus*) and the brown bullhead (*Ameiurus nebulosus*), which had both spawned in the Dallas Aquarium several times. There was then a strong quivering movement on the part of the male. This was repeated from time to time and was observed at irregular intervals for almost two weeks. When the female was ready to spawn she began to deposit her eggs in a depression in the gravel that she and the male had prepared, behind an old tree stump on the ledge to the rear of the tank. As spawning sites in nature these fish seem to prefer shelves with overhanging ledges, hollow logs and well protected places.

The female expelled the eggs in masses of 30 to 50 which were then fertilized by the male. At this time the two fish lay side by side, with heads in the same direction, turning their bellies together. At times the female quit the nest for a few minutes while the

male fluffed and arranged the eggs. During this observation the egg-laying was carried out in about four and one-half hours. Within an hour after the female had quit spawning she was removed from the tank, as past experience had shown that she would crush or eat the eggs. The male took up guard over the nest at once.

The male hovered over the eggs, keeping his body only a few inches above them. The ventral fins were used to fan the eggs. Sometimes the ventral fins were used like hands, lifting the entire mass from the floor, gently fluffing and turning them in a half-arc. This process was repeated several times a day. At times the male moved the egg mass a distance of 8 to 10 inches by means of his mouth or ventral fins. He was often observed to arch his caudal fin, slip it under the entire egg mass and give it a good shaking in a movement much more violent than one would expect to see. Frequently the male stood on his nose so to speak, to look the eggs over and to drag his barbels over the mass. This action was repeated frequently enough to lead to the assumption that it was done for some definite reason. During this period of fanning the male made frequent trips to the glass front of the tank, opening his mouth wide as if to frighten the observer. It was not possible to use a bottom glass from the surface as he would charge the glass almost as soon as it was put into the water. On the fifth day the male made a very thorough inspection of the nest. During this inspection he lifted out a mass containing about 1,250 eggs and carried them halfway across the tank and dropped them on the bottom. These were picked up with a dip net and found to contain live embryos. These eggs were then placed in a small aquarium with an air hose and hatched in the evening of the seventh day after spawning. A second mass of eggs, thrown out of the nest on the sixth day was left where the male put them. These eggs hatched in the morning of the seventh day. By mid morning of the eighth day all of the eggs had hatched and the young were darting about the nest, resembling the popping of corn. The fry upon hatching were about 3/16 of an inch long and had an unusually large yolk sac. After the eggs hatched the male remained with the young but elevated his position about 12 to 15 inches above the fry. He still did not permit anyone to get close to the nest and made regular runs at anyone in front of the glass.

The young fish upon hatching had no color other than the two black eyes and the clear but opaque yolk sac. The second day the young had become a cream to brown color but not very dark. The yolk sac was completely absorbed by the sixth day and the fry had taken on a very dark color, almost black. The fry were removed to a rearing pond in the hatchery where they would have room to grow and feeding would not be so great a problem. They were placed in an acre and half pond and left until October 1st at which time the pond was drained. Forty-one thousand fingerlings about 8 inches long were recovered. Since 40 fish weighed a pound, the total weight was estimated as 1,025 pounds.

An interesting aftermath of the spawning came when the female was returned to the display tank. She at once went to the corner where the eggs had been and made a thorough inspection. The male moved from her corner and returned to his and she took up her old place apparently content. At two the following morning the night-watchman reported that the two fish were fighting but that after being separated they returned to their respective places in the tank. It was not until late in the afternoon that day that they started fighting again. After sparring for a few minutes the female backed away from the male a distance of about 18 inches, made one rush and struck him in the side. He rolled over and floated to the surface, belly up. He was removed to a reserve tank and lived for two days then died. An autopsy revealed that the blow had injured his intestine, stomach and several other organs. What this behavior indicates we have not been able to guess.

Pilodictis olivaris has also spawned in the John G. Shedd Aquarium at Chicago. Walter H. Chute (John G. Shedd Aquarium, Annual Report of the Director, 1935) has given a figure of a male guarding a nest with a large cluster of eggs. Chute's observations, presented in detail by Breder (1935, Zoologica, 19: 152, 156, figs. 22–23), are confirmed by those here reported.

Other species of Ameiuridae are known to have somewhat similar breeding habits. The most detailed accounts published are those of Breder (1935, *op. cit.;* 1939, Zoologica, 24: 367–378).—Pierre A. Fontaine, *Director, Dallas Aquarium and Hatchery, Dallas, Texas.*

VARIATION IN THE NUMBER OF PYLORIC CAECA AND OTHER NUMERICAL CHARACTERS IN CHINOOK SALMON AND IN TROUT.—While examining a number of possible racial characters for study in the chinook salmon of the Willamette River, Oregon, pyloric caeca were counted in a series of samples. Comparison of these counts with those made by McGregor (1924, *Calif. Fish and Game*: 138–150) on chinook salmon from the Klamath and Sacramento rivers casts doubt upon the conclusion of McGregor that the numerical variation of these structures is a useful means for separating river races of salmon in the sea. This paper deals with these data and other numerical variations in salmon and trout.

TABLE I

The number of pyloric caeca in salmon from the Cowlitz River, Washington, and branches of the Willamette River, Oregon, compared with counts from the Sacramento and Klamath rivers, California, made by McGregor.

Number of caeca	Number of Fish					
	Klamath River	Sacramento River	Cowlitz River	Middle fork of Willamette River	McKenzie River	South Santiam River
91– 95	1	..	..	..	..	..
96–100	..	..	..	..	..	..
101–105	1	..	..	..	..	..
106–110	3	..	..	1	..	..
111–115	2	..	..	..	..	..
116–120	6	..	..	..	..	3
121–125	9	..	..	..	1	1
126–130	10	..	1	3	2	5
131–135	9	2	4	4	3	12
136–140	3	2	3	6	3	13
141–145	8	1	5	8	1	13
146–150	6	6	7	2	9	12
151–155	5	2	5	10	12	20
156–160	..	4	5	11	5	10
161–165	1	9	5	15	4	7
166–170	..	4	4	18	8	9
171–175	..	6	3	8	3	5
176–180	..	9	2	15	5	2
181–185	..	5	4	7	6	2
186–190	1	6	2	4	1	3
191–195	1	12	..	2	3	..
196–200	..	6	..	3	3	..
201–205	..	4	..	1	..	1
206–210	..	2	..	2	..	..
211–215	..	1	..	..	..	..
216–220	..	..	..	..	1	..
221–225	..	..	..	1	..	..
226–230	..	..	..	..	..	..
231–235	..	..	..	1	..	..
236–240	..	..	1	..	..	..
241–245	..	..	..	1	..	..
Total	66	81	51	123	70	118
Mean	132	176	157.5	165.8	162.5	150.5

Pyloric caeca were removed from fish at egg-taking stations on the Middle Fork of the Willamette, McKenzie, and South Santiam rivers, Oregon (all tributaries of the Willamette River), and on the Cowlitz River, a tributary of the Columbia River in western Washington. The latter collection was made available through the Washington State Fisheries Department. All fish were of the "spring run," that is, salmon that had entered the Columbia River before August. Those taken in the Willamette tributaries are part of one of the earliest chinook salmon runs, the fish having entered the Columbia during January, February and March.

The samples were preserved in strong formalin solution immediately on collection. After the samples were thoroughly hardened, the caeca were grasped with forceps by their bases and carefully pulled off from the loop of intestine to which they communicate. The isolated caeca were placed in a separate vessel of liquid from which the counts were made and verified. Branched caeca were of infrequent occurrence. If the branches were shorter than the united part, it was counted as one caecum; if the branches were longer than the base, they were counted as two caeca. Caeca with more than a single branching were not observed. There were 20 branched caeca in the samples from 362 fish, one fish having five caeca branched.

Table I shows the results of the counts, together with the records secured by McGregor from fish taken in the Sacramento and Klamath rivers. The means were calculated before the counts were grouped.

TABLE II

Variation in the number of vertebrae and gill rakers in chinook salmon from the Willamette River. Gill raker data are for fish from the McKenzie River.

Number of Vertebrae	Number of fish		Number of Gill Rakers	Number of fish			
	McKenzie River	Middle fork of Willamette River		1st* arch	2nd arch	3rd arch	4th arch
65	1	...	14	...	...	...	3
66	6	...	15	...	...	...	3
67	2	7	16	...	...	...	5
68	...	9	17	...	...	...	1
69	...	6	18	...	...	1	...
			19	...	...	3	...
			20	...	1	7	...
			21	...	4	3	...
			22	...	3	1	...
			23	2	3	...	...
			24	4	3	...	...
			25	6	...	...	...
			26	1	...	...	...
			27	1	...	...	...

* The first arch varied from $9 + 14$ and $10 + 13$ to $11 + 16$; second arch from $7 + 13$ to $9 + 15$; third arch from $7 + 11$ to $9 + 13$; and the fourth arch from $5 + 9$ and $6 + 8$ to $7 + 10$.

The difference in mean pyloric caeca count in fish taken from the tributaries of the Willamette and from the Cowlitz is not so pronounced as is the difference between the counts for the fish from the two California rivers, or between the Klamath River fish and those from the Cowlitz and Willamette. There are, however, differences in the means for the pyloric caeca from the northern river fish which were shown by analysis of variance to be significant. Detailed comparisons show that the difference in the mean pyloric caeca counts for the South Santiam and McKenzie fish is 4.4 times the standard deviation of the difference, and that for the South Santiam and the Middle Fork of the Willamette fish is 6.4 times the standard deviation of the difference. For all other combinations of samples from northern streams the difference in means is less than 3 times the standard deviation of the difference.

While the tendency is for the counts from the northern fish to correspond more nearly with those from the Sacramento than with those from the Klamath, they covered nearly the whole range of counts reported for the Klamath. Among Willamette and Cowlitz samples were individual chinook salmon with higher numbers of caeca than any recorded from the California streams. The largest number found in a fish was 244. This is somewhat greater than the figure that is given in the literature for the upper limit of the range for the species. It is interesting to note that isolated high numerical variation occurred in all samples except that from the Sacramento River.

The similarity in the number of caeca in fish from the three tributaries of the Willamette River may be the result, in part, of mixing of stocks in the past by the transfer of eggs between the streams. Such transfers have occurred in the course of fish cultural practices, but so far as is known no extensive mixing has been carried out. There is the further possibility that some straying occurs between the forks of the Willamette. No recorded transfers have been made between the Cowlitz and the tributaries of the Willamette. The possibility of straying between the two river systems appears remote. Cowlitz fish enter the Columbia River much later than Willamette fish, although the former are still "spring run" salmon. Straying of the later running Cowlitz fish into the tributaries of the Willamette is a practical impossibility because nearly every year the falls of the Willamette is impassible for fish at the time that the Cowlitz River spring chinook salmon are in the Columbia.

The wide range of variation observed in the number of pyloric caeca, and the slight difference between the numbers of caeca in fish from different streams appear to invalidate McGregor's suggestion for the use of this character for distinguishing river races of chinook salmon, and pyloric caeca are quite unreliable for the identification of fish in the sea with their home stream. This conclusion is similar to that made by Belding (1939, Trans. Amer. Fish. Soc.: 285–289) for the Atlantic salmon, and by Parker (1943, COPEIA: 190–91) for chinook salmon of California rivers.

The number of vertebrae and the number of rakers on all of the gill arches have not been published for many Pacific salmon. The few counts made on chinook salmon from the Willamette River are shown in Table II.

Pyloric caeca were counted from a few trout caught in the Willamette drainage. This character nearly separates cutthroat and rainbow trout. Pyloric caeca in 11 cutthroat trout from the Middle Fork of the Willamette River varied from 27 to 40, with an average of 33. Eight rainbow trout from the same stream had 44 to 61 caeca, averaging 54; and eight from the McKenzie River had 39 to 58 caeca, with an average of 46.—LAWRENCE D. TOWNSEND, *2958 S. W. Dosch Road, Portland 1, Oregon.*

A NEW NAME FOR *MYCTOPHUM OCULEUM* CHAPMAN.—In 1939 (Proc. U. S. Nat. Mus. 86: 524–527, fig. 65) the writer described a new species of lantern fish from the northeastern Pacific Ocean under the name *Myctophum oculeum.* Unfortunately this name was preoccupied by Garman (1899, Mem. Mus. Comp. Zool. 24: 260, pl. 56, fig. 2). Later in 1939 Bolin (Stanford Ichthy. Bull. 1 (4): 89–156, 29 figs.) revived the genus *Electrona* Goode and Bean for the fishes of this relationship. The present species falls within that genus as defined by Bolin and is here renamed *Electrona thompsoni* after William Francis Thompson in respect for his work in economic fisheries, ichthyology, and teaching. The holotype remains the same, USNM No. 108146.

Bolin (*loc. cit.*, 1939: 98–99) described as new *Electrona crockeri,* which is quite similar to *Electrona thompsoni,* from a single specimen 14.7 mm. in standard length. His description was compared with paratypes of *Electrona thompsoni* of the same length as his specimen and the following differences were noted: *E. crockeri*—anal originating under anterior half of dorsal; adipose inserted only slightly anterior to end of anal base; insertion of pelvics about midway between insertion of pectorals and dorsal origin, fin extending almost to anal origin; anal rays 21; Op_2 large, its diameter almost equal to width of maxillary and on level of lower end of pectoral base; PVO_2 slightly anterior to lower end of pectoral base; VLO directly over posterior end of pelvic base, about on level of lower end of pectoral base; 4 VO evenly spaced, very close together, the anterior end of each of the last three organs almost directly over the posterior end of the preceding one. *E. thompsoni*—anal originating under posterior third of dorsal; adipose lying over posterior fourth of anal fin; insertion of pelvics under or only slightly ahead of dorsal, fin extending to third or fourth anal ray; anal rays 22 to 25 (average 23.5); Op_2 small, its diameter much less than width of maxillary, well above level of lower end of pectoral base; PVO_2 midway up base of pectoral; VLO ahead of posterior end of pelvic base and above level of lower end of pectoral base; 4 VO evenly spaced and well separated.

It may be that some of these differences will disappear when a larger series of *E. crockeri* is available for comparison, but in view of the fact that the above comparison was made between fishes of the same size it is believed that the two species will be found to retain their specific distinctiveness.

Upon reading the above Dr. Bolin (in letter) reports having obtained another specimen of *E. crockeri,* about 13 mm. in standard length, from 10 miles due west of Pt. Pinos. He reports it to check well with the type, but adds the following notes: "Dorsal seems to have 12 rays; the anal 20. The adipose fin is slightly (about a photophore width) farther advanced than is shown in my figure. The pelvic base may be slightly behind the midpoint between pectoral base and dorsal origin, but only a very tiny bit. The photophores are practically identical with those of the type, but the SAO series is as straight and horizontal as if they had been put on with the aid of a stretched line and a spirit level. If the photophores in your small specimens are as minute as you indicate in your figure, I should stress the size if I were you. The outlines in my figure represent the outline of the entire pigmented vesicle. While the VO series in my second specimen does not show organs which overlap, they are very close, the distance between the individual organs being much less than the diameter of the organs themselves—about one-fourth the diameter, I should say. The Prc organs are so large and close that they are actually in contact. Another difference between my figure and yours is the spacing of the PO organs. The new specimen is just like the type in having the anterior two organs widely separated from the others and the posterior three bunched into a tight series.—". —WILBERT MCLEOD CHAPMAN, *California Academy of Sciences, San Francisco, California.*

A PERPETUATED ERROR CONCERNING THE CAPITAINE, *LACHNO-LAIMUS MAXIMUS* (WALBAUM), IN TEXAS WATERS.—Stevenson (1893, Rept. U. S. Commissioner Fish and Fisheries 1889 to 1891: 375–420) and Collins and Smith (1893, Bull. U. S. Fish Comm. 11: 93–184) in their statistical reports on the coast fisheries of Texas and the fisheries of the Gulf States, respectively, listed *Lachnolaimus maximus* as produced commercially on the Texas coast in 1889 and 1890.

Collins and Smith (1893) used common names in tabulating the species. In a table (pp. 99–102) they list in order, local common names, Latin names and the common names under which the fishes were tabulated in the statistical tables. Here *Lachnolaimus maximus* is listed twice under the local common names of hogfish and sailor's choice. The Latin name was given as *Lachnolaemus falcatus.* In each place it was stated that *L. falcatus* was listed in the statistical tables as the sailor's choice, and 26,750 pounds of sailor's choice were listed as the Texas production for 1889 and 25,850 given as the production for 1890. Over half of this amount came from the Galveston region. Mr. J. L. Baughman first called my attention to this fact and we both took the tables to mean, as they definitely indicated, that fifty years ago several thousand pounds of *Lachnolaimus maximus* (*Lachnolaemus falcatus*) were produced commercially on the Texas Coast. This is in error as I shall show, but I (1941, Amer. Midl. Nat. 26(1): 194–200) perpetuated the error and called attention to the strange fact that whereas *L. maximus* was produced commercially from the Galveston area fifty years previously, it had become so rare that the commercial fishermen of today did not recognize the fish when they saw it.

The puzzling disappearance of the capitaine from Texas waters was relayed to the back of my mind, but my curiosity was increased by the slowly gathered evidence that none of the older commercial fishermen of the Texas coast were acquainted with the species. This led to further study of the literature and the following facts were brought to light. Jordan, Evermann and Clark (1930, Rept. U. S. Commissioner Fish., 1928, Part II) list two other well known Texas fish under the name of sailor's choice. They are the sparid, *Lagodon rhomboides* (Linnaeus), called in Texas the pinfish, and the haemulid, *Orthopristes chrysopterus* (Linnaeus), called in Texas pigfish, piggy perch and rarely, hogfish. They also give hogfish as one common name of the latter fish and as one common name of *L. maximus.* The data on which the paper of Collins and Smith (*op. cit.*) was based were collected by about twenty field workers, many of whom doubtless had little knowledge of the classification of fishes. The authors reported no *O. chrysopterus,* or grunts, as they would have listed the species, from Texas. Today this species is listed with other small species lumped together as scrap fish in Marine Products Reports turned in to the Texas Game, Fish and Oyster Commission.

Confusion of species could have easily arisen. It is concluded that confusion actually did arise and that the production of sailor's choice for the Texas coast in 1889-90 reported by Collins and Smith (*op. cit.*) actually referred in all likelihood to *O. chrysopterus,* a

species common on the coast today, and not to *L. maximus,* an unknown or rare fish in Texas coastal waters.

Apparently the capitaine, *L. maximus,* does occur occasionally on the snapper banks several miles off the Texas Coast. I have seen a few mounted specimens reported to have come from there.—GORDON GUNTER, *Game, Fish and Oyster Commission, Rockport, Texas.*

FURTHER OBSERVATIONS ON THE FOOD OF NEWLY PLANTED BROWN TROUT (*SALMO TRUTTA*) IN SIX MILE CREEK, NEAR ITHACA, NEW YORK.— The writers have previously reported the food of recently planted brown trout (*Salmo trutta*) in Six Mile Creek, New York, in the spring of 1942 (1942, COPEIA: 192). Another planting of two-year old brown trout (8–14 inches) in the same water during the 1943 season made it possible to continue observations on this subject. The trout were planted on April 16, and as in the previous year, were from the New York State Fish Hatchery at Rome. The water temperature at the time of planting was 33° F.

On April 17, 20 to 27 hours after stocking, the stomach contents of 40 of these newly planted brown trout were examined. The fish were taken by angling, largely on artificial lures. The water temperature was 36° F. All of the 40 specimens examined held food ranging in quantity from two or three insect nymphs to several hundred organisms occupying a volume of 4 to 6 cc. The stomachs of most of the trout contained large quantities of food (8 specimens had eaten only a few scattered insects), indicating that considerable and prompt feeding activity had taken place since stocking.

Qualitatively, the important food organisms were mayfly nymphs (about 90%), represented largely by *Baetis.* Scattered nymphs of *Iron, Paraleptophlebia* and *Ephemerella* were also found. The other food (10%) consisted of small Diptera pupae, Chironomid larvae, nymphs of stoneflies (*Isoperla, Leuctra*), caddis larvae (*Hydropsyche, Ryacophila*), plant material (hemlock needles, an ash seed, and a beech bud), two sowbugs (*Asellus*), gravel, ranging in diameter from 3 to 10 mm., and well-digested fish remains. The fish remains consisted only of the vertebral column or maxillary bones (remains present in 9 specimens). In all probability these had been eaten prior to planting, considering their advanced digested condition and the low water temperature in which the trout were planted. It was ascertained that prior to planting these trout had been held temporarily in a pond where there were some stray or escaped small trout. Although the 40 trout examined were taken over a three-quarter mile stretch of stream, the food found in the individual stomachs was qualitatively remarkably similar, i.e., the predominant food eaten was nymphs of *Baetis.* One exception consisted of a specimen in which stonefly nymphs were most abundant.

The gravel had been ingested either accidentally or with intent, for it clearly was not the remains of the stone cases of caddis larvae. (Similar instances of gravel in the stomachs of newly planted brook trout, *Salvelinus fontinalis,* have been noted. In April, 1935, the junior author examined a number of brook trout within 24 hours after planting in the Fenton River, near Storrs, Connecticut. These fish had ingested enough free gravel, up to 12 mm., to distort the external appearance of the fish. Food organisms occurred infrequently. Two other observations of free gravel in brook trout stomachs have been made by the writers in the Van Pelt stream, a spring tributary of the Six Mile Creek mentioned previously, in May of 1941 and 1942. Several 9 to 11 inch trout examined within three days after stocking held considerable quantities of gravel.)

On the succeeding day, April 18, 16 more of the newly planted brown trout were examined. The food was qualitatively similar to that of the previous day, and the stomachs were gorged with food. Occasional fish rose to take adults of the stonefly, *Leuctra,* which were drifting on the surface. In the late afternoon of this day melting snow had roiled the creek water and both volume and turbidity were increased by rain on the next day.

On April 21, with a water temperature of 39° F. the stomachs of 14 more hatchery trout were examined. This was after the water had remained high and roily for about 2 days. The stomachs of these fish held a considerably less volume of food than those examined on April 17 and 18 and the food was more diversified. This was scattered among about twenty genera of organisms, which in addition to those already named included *Nigronia, Sialis, Simulium, Isonychia, Aeschna,* as well as spiders, ants, earth-

worms, and slugs. Nymphs of *Baetis* were most frequent in two stomachs, while nymphs of *Ephemerella* predominated in five.

No "wild" trout were observed to be taken (as wild fish are meant carry-overs from previous plants or naturally spawned stock). However, from previous experiences and observations this section of the stream is known to be populated by a fair number of wild trout.

The writers are indebted to members of the Fly Tyers Club at Cornell University for submitting their catches for examination and for making pertinent observations on angling conditions.—DWIGHT A. WEBSTER and G. SCOTT LITTLE, *Laboratory of Limnology and Fisheries and Department of Physical Education, Cornell University, Ithaca, New York.*

THE USE OF SODIUM PERBORATE (NaBo₃.4H₂O) IN CONTROLLING *EPIBDELLA MELLENI*, BACTERIA AND ALGAE IN SALT WATER AQUARIUMS. —The heavy infestation of *Epibdella Melleni* on Florida Key fishes, particularly the groupers, angelfishes, and related species, and the resultant high mortality in the large aquarium tanks at Marine Studies, Marineland, Florida, prompted the author to conduct a series of experiments to find a suitable parasiticide.

Four essential specifications had to be met before such a parasiticide could be considered practical. The aquarium tanks containing thousands of gallons of water had to be treated while in full operation, and at a low cost. The treatment had to be carried on without requiring too much additional labor. Loss of specimens during the course of treatment had to be kept at a minimum.

Among the scores of chemicals and drugs tested, late in 1941, two gave great promise. Formaldehyde, one part in two thousand, and sodium perborate, one quarter gram to the gallon of sea water, proved to be lethal to the parasite. Both substances, however, also proved to be lethal to invertebrates.

Formaldehyde was soon discarded because of its narrow margin of safety and the difficulty of procuring a sufficient amount during the national emergency.

After the initial tests in the small aquaria, the experiments with sodium perborate were continued in the 1500-gallon photographic tank situated on the Studio grounds.

When the experiments were begun, many of the specimens were infested with *Epibdella Melleni,* there was a heavy algae growth which necessitated daily cleaning, and there was considerable turbidity due to bacteria and other organic matter in suspension.

A treatment program was initiated that required a minimum amount of labor. The influent and effluent valves to the tank were closed. The required amount of sodium perborate was placed in a wash-tub and put in solution with sea-water. The solution was then sprinkled over the surface of the water in the tank with a sprinkling-can. Oxidation was permitted for five minutes in the still water, before the influent and effluent valves were turned on again. The scum that rises to the surface is carried off, usually in less than an hour.

The specimens will react violently for a minute or so after the treatment is administered, but soon settle down to normal swimming or come to rest on the bottom of the tank.

The initial dose in each series of experiments was one gram of sodium perborate to the gallon, and each succeeding dose, administered on alternate days, was one quarter gram to the gallon.

The majority of infested fishes made rapid recovery. An observer can readily see the parasites detach themselves from the infested specimens and float off. Several fishes with one eye completely destroyed healed up nicely. The appetites of the specimens improved and their colors became more vivid. The turbidity disappeared and the water became crystal clear. All of the algae was destroyed in less than a week, making daily cleanings unnecessary.

Treatments in the photographic tank were continued for three months so as to make certain that the sodium perborate had no deleterious effect on the specimens.

By the time we were ready to treat the large aquarium tanks the supply of sodium perborate had already been restricted due to the defense program. We did, however, manage to secure some 8,000 pounds, enough for one series of treatments.

The same program of treatment was followed. The solution was sprayed over the

surface of the tanks with hoses, on alternate days, for a period of eight days. In so doing we hoped to kill the free swimming larvae as fast as the eggs, which had already been laid, could hatch.

The large tanks appeared free of the parasite for a few days, but we soon discovered that the treatment would have to be continued over a much longer period to completely eradicate *Epibdella*. Some very susceptible species, particularly the large jewfish, continued to harbor the parasite.

Less than a dozen specimens in the large tanks were unable to stand the shock of the treatments, and these were found to be either badly infested or otherwise diseased. All invertebrates perished during the treatments, some however, were able to stand three or four doses of sodium perborate before they succumbed.

Sodium perborate was used very effectively in our trucking operations. Most of our colorful fishes were trucked in canvas bags from Tavernier, Florida, to Marineland, a distance of some 425 miles. At the start of our trucking operations it was necessary to stop at intervals, run a Ph of the water, and often take on new water. After we began using sodium perborate we could, by the addition of one quarter gram of the chemical to the gallon of water, carry a maximum load of specimens the entire 425 miles and arrive at Marineland with a Ph of 8.3 or better.

The trucking mortality was reduced to less than one percent, and we were secure in the knowledge that parasitic as well as bacterial action had been checked, and skin abrasions and other injuries on the specimens were healing while enroute.—ARTHUR H. SCHMIDT, *P. O. Box 696, Ft. Lauderdale, Florida.*

Herpetological Notes

CALIFORNIA RECORDS OF THE WESTERN SPADE-FOOT TOAD.—The distribution of *Scaphiopus hammondii* Baird west of the Sacramento-San Joaquin Valley in California is little known, except far south in the Los Angeles area. To the north there seem to be only two records from the coastal region. In 1930 (Proc. Biol. Soc. Wash., 43: 61) I mentioned some metamorphosing tadpoles, from near Salinas, Monterey County, which I had unearthed in a miscellaneous accumulation of amphibian material in the Stanford Natural History Museum; the locality label bore only the date of collection, May 5, 1922. The other record is that of Tanner, in his 1939 review of the spade-foot toads (Great Basin Naturalist, 1: 17), who lists a single specimen taken by T. I. Storer at Berkeley, Alameda County, in July, 1938. No other details are given.

I am now able to confirm the presence of *Scaphiopus hammondii* in the Salinas Valley. During a recent field trip of the Stanford Natural History Club, four fine adults were taken at Mission San Antonio, Monterey County, between 9 and 10 P.M., May 9 and 10, 1941, by R. S. Ferris, M. H. Storey, and Elizabeth Hammerly. The toads were hopping about among the willows growing along the stream in the public picnic ground at the Mission. These specimens are now in the Museum collection, Nos. 6398–6401.

Records of *Scaphiopus hammondii* are not common, even in the southern coastal sector and the San Joaquin Valley; specimens in the Stanford collection represent the following localities: south of Santa Maria and north of junction of U. S. Highway 100 with the Lompoc road, Santa Barbara Co., Sept. 11, 1941, M. H. Storey; south of Guadelupe Lake, between junctions with roads to Betteravia, Santa Barbara Co., Sept. 11, 1941, M. H. Storey; and 2 miles west of Coalinga, Fresno Co., May 27, 1941, M. H. Storey and Donald Grant.

It is probable that spade-foots are to be expected in almost any of the dry, Lower Sonoran areas in western California, but the creatures are so elusive, their breeding season so short, and the region so large that distributional records are still few.—GEORGE S. MYERS, *Natural History Museum, Stanford University, California.*

INDIGO SNAKES FEEDING UPON POISONOUS SNAKES.—Captive specimens of the indigo snake, *Drymarchon corais couperi* (Holbrook), observed over a period of several years, readily fed upon various species of *Thamnophis* and *Natrix*. They seized these snakes by any part of the body, then, by lateral movements of the jaws, worked down over the head before beginning the swallowing operation.

In an attempt to determine whether or not any discriminating reaction would take place, three poisonous snakes were offered to a *Drymarchon* 2083 mm. in length, with the following results.

A young *Crotalus horridus atricaudatus*, 400 mm. in length, when introduced into the cage containing the *Drymarchon*, was attacked and swallowed immediately. The rattler did not offer to bite, and the indigo snake showed no hesitation in attacking.

An adult *Agkistrodon mokeson cupreus*, 635 mm. in length, was then placed in the cage. Again the indigo snake attacked, but this time seized the prey by the head, and in fact seemed to avoid any other portion of the body. Before swallowing the copperhead, the indigo snake lacerated its head by "chewing" with lateral movements of the jaws.

In an attempt to make a motion picture record of such an encounter the *Drymarchon* was placed in an enclosure 10 feet square, and given a small water snake to whet its appetite. As soon as the *Natrix* had been swallowed, an adult *Crotalus horridus atricaudatus*, 1016 mm. in length, was placed in the enclosure. The rattler showed no alarm in the presence of the indigo snake, even crawling over the latter. The indigo snake then became alert, and seized the rattler, first by the tail, then at the mid-body, releasing its grip on both occasions in a few seconds. The *Crotalus* still showed no anger or fear. The *Drymarchon* then located the head of its prey, and crawled along parallel to it, so that the two animals were neck and neck, for more than a minute. Then, with a sudden swift move, it seized the rattler by the head so that its jaws were pinned shut.

The victim writhed and twisted strongly, but was held down by a coil of the *Drymarchon*, which constantly "chewed" its head. As the *Drymarchon* pulled on the head of the rattler, while pinning its body down, the victim was stretched until the anterior part of its body was taut. Once the rattler escaped, but was immediately recaptured, again by the head. After five minutes of this treatment, the engulfing operation was begun.

It appears that the indigo snake usually seeks the head of a poisonous snake before attacking, and that the laceration of the head of the prey is deliberate. In none of the observed cases did the victim find opportunity to bite. The question remains as to whether this behavior is a specific response to poisonous snakes, or whether it might be elicited if large harmless snakes were offered as food.

It is interesting to note that at no time until it was seized did the *Crotalus* show any alarm. There was no reaction like that reported by Cowles (1938, COPEIA: 13) for *Crotalus viridis oreganus* in the presence of a king snake.—HUGH L. KEEGAN, *Zoological Laboratory, State University of Iowa, Iowa City, Iowa.*

AN ALBINO FOX SNAKE FROM IOWA.—On June 24, 1942, an albino fox snake, *Elaphe v. vulpina* (Baird and Girard), sent in by Mr. A. I. Nietzel of Muscatine, Iowa, was received by the Department of Zoology of the State University of Iowa: it is a male measuring 1220 mm. in length, found DOR near Wapello, Iowa. It has 203 ventrals and 54 caudals.

This specimen exhibits a type of 'albinism' similar to that described for other species of North American snakes by various authors. The pattern appears to be normal, with 41 dorsal blotches. These, as well as the lateral blotches, are between Ochraceous and Ochraceous-Buff in color. Some of the scales at the edges of the blotches, particularly on the posterior part of the body, are margined with Ochraceous-Rufous. This tendency is especially conspicuous in the lateral blotches. The area between the blotches is Cream-Buff. The labials, temporals, pre- and postoculars are tinged with Ochraceous-Rufous. The iris is Ochraceous-Buff. The spine-like tip of the tail is Vinaceous-Rufous. The dark patches on the ventral surface are Cinnamon-Drab, and the area between the patches is cream. (The nomenclature of colors is according to Ridgway's *Color Standards*.)

This specimen is deposited in the museum of the State University of Iowa.—HUGH L. KEEGAN, *University of Iowa, Iowa City, Iowa.*

RECORDS OF THE PURPLE SALAMANDER IN MARYLAND.—During field work in the Blue Ridge region of Maryland, several purple salamanders, *Gyrinophilus porphyriticus porphyriticus* (Green), were obtained. These apparently represent new eastern records for this salamander in the state. The published records by Dunn (1926, The Salamanders of the Family Plethodontidae: 265) and McCauley and East (1940, COPEIA, 1940: 121) indicate that this species is restricted to Garrett County in extreme western Maryland. Specimens in the Carnegie Museum and the United States National Museum are from Garrett County only. Physiographically, this county is representative of the Appalachian Plateau Province of the Appalachian Highlands. The presence of the purple salamander east of Garrett County in Maryland was anticipated, since Dunn (*loc. cit.*: 260) indicates a physiographic range including the Appalachian Highlands in all of its subdivisions, except the southern Blue Ridge, and since the species ranges farther to the east in adjacent Virginia and Pennsylvania. The new records are as follows:

FREDERICK COUNTY.—No. 375, Catoctin Mt., near Middlepoint, Catoctin Creek drainage, elevation 1,200 ft., June 13, 1940; No. 418, Catoctin Mt., near Yellow Springs Monocacy River drainage, elevation 1,100 ft., Nov. 24, 1940 (skeletonized); No. 583, Catoctin Mt., Steep Creek, Frederick City Watershed, Monocacy River drainage, elevation 1,300 ft., Aug. 31, 1941.

WASHINGTON COUNTY.—No. 670, South Mt., near Euclid, Antietam Creek drainage, elevation 1,600 ft., Feb. 1, 1942 (larva).

The specimens were collected in or near clear, cold springs or spring-fed streams. The larva was taken from a spring pool; one of the adults from under a rock beside a spring; and the other two adults from under rocks and loose gravel in spring-fed streams near their sources.

These records extend the range of *G. p. porphyriticus* in Maryland from Garrett County in the Appalachian Plateau Province about 100 miles to the east and into the Blue Ridge Province. There are still no published records for the intervening area, which is representative of the Valley and Ridge Province.

Another species frequently associated with the purple salamander in Maryland, *Desmognathus phoca*, likewise on record from Garrett County, should be looked for farther to the east.—J. A. FOWLER, *The Sidwell Friends School, Washington, D.C.*

A TECHNIQUE FOR OBTAINING TURTLE EGGS FOR STUDY.—The difficulty of obtaining eggs from turtles is one of the primary reasons for the lack of information on their eggs and incubation periods. Only rarely does an investigator have an opportunity to collect eggs known to have been deposited at a given time; and captive females must be provided with a proper depth of soil or sand if one wishes to secure normal eggs. If not so provided, the turtle may retain the eggs for a long period, or lay them at irregular intervals and frequently injure them in the procedure.

Studies on the breeding habits of the turtles of southern Illinois required a method that would enable the investigator to: (a) determine the presence of oviducal eggs and the time when they are ready for deposition; (b) remove the eggs without injury. The presence of oviducal eggs may be determined in all those species not having the ability to close the shell opening by holding the female in a vertical position and palpating the abdomen with the forefinger of each hand inserted into the hollow just anterior to the rear limb. In most individuals the entire abdominal area can be explored in this fashion, and the presence of oviducal eggs is easily determined.

The investigator may also determine the stage of calcium deposition and thus judge when the eggs may be removed. In turtles that lay hard-shelled eggs the egg may be judged ready for removal when the investigator cannot indent the egg within the oviduct. In species that lay eggs with a flexible shell, the eggs may be judged ready for removal when the shell offers some resistance to indentation and tends to return to its original shape. Some practice may be required before consistently satisfactory results are obtained.

Eggs may be removed by dissection. When the plastron is removed the oviducts are easily visible. The posterior end of each oviduct may be clipped and the eggs gently stripped out. Clutches of eggs so removed have been repeatedly incubated successfully.—FRED R. CAGLE, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

OBSERVATIONS ON THE LIFE HISTORY OF *AMPHIUMA MEANS*.—On February 3, 1933, the writer made a trip to the Everglades, at a point about 25 miles south of Royal Palm State Park, Dade County, Florida. At the time the water level was very low, but the dried up scum and decayed vegetation kept the marl moist.

A nest of *Amphiuma means means* Garden, the eel-like salamander, was found at the edge of a dried up pool under a board sunk by half of its thickness into the muck. There were 49 eggs in the clutch, which appears to be an abnormally low number. The female was rather small (39 cm. long), covered with cysts, and in an emaciated condition. The board was covered with the dry and caked marsh scum and decayed vegetation. This covering apparently acted as an insulator against the baking action of the sun and conserved moisture for the eggs.

The female was coiled around the eggs when the board was lifted in such a manner as to keep them clear of the ground, reminding one of a similar habit on the part of *Desmognathus fuscus*. On exposure to the light she became frightened and spread herself out along the outer edge of the nest, so that the eggs settled down to the bottom; but she remained in attendance.

The nest was elliptical, 5 inches long and 3 inches wide, with a depth of 1 inch. At one end of the nest was a burrow $\frac{13}{16}$ inch in diameter, leading in a horizontal direction from the nest. At a point 18 inches from the nest the burrow lead abruptly to subterranean crayfish burrows. The nest appeared to have been hollowed out by pressure from the amphiuma's body against the marl, during the period when the water level was higher and the marl soft and pliable. The ceiling of the nest consisted of the under side of the board covered with a thin layer of marl. The sides were sufficiently concave to receive about one-half of the amphiuma's body and the bottom was leveled and smoothed off by pressure. The entrance to the burrow was sealed with a thin layer of marl, indicating that it was made at the time of nest building. I suspect the brooding female remains with her eggs in the cool moist nest chamber until the embryos are fully developed and until the water level in the marsh rises to release the matured young from the egg envelopes. In this area heavy rains may be expected in June and this corresponds with the hatching period of a set of eggs reared by the writer.

The eggs were knotted together into the form of a flattened ball. On separating the mass it appeared to consist of one long string in the form of a rosary, similar to the egg strings of *Cryptobranchus*. The string might be compared with a long transparent tube bulging with eggs at intervals of from 5 to 10 mm. The external diameter of the tube between the eggs was 1 mm. The thin tube extended several inches beyond the end of the eggs and served to knot and bundle the eggs together. The average size of the eggs was 10 by 10.5 mm. At the time the eggs were found the embryos were distinctly visible through the transparent envelopes and the clear liquid in which they floated. The white head and tail were distinctly visible beyond the yoke, indicating that the eggs had been developing for some time and may have been laid during the middle of January.

The development of the embryos was observed to February 22, when they had reached a length of 36 mm., chromatophores had formed on various parts of the body and the formation of the mouth was advanced. A second batch of eggs was received on February 10, 1935, in which the embryos had reached about the same stage of development as the first lot when they were found. This second batch of eggs was successfully hatched on June 21, 1935. If this lot was laid about the middle of January the incubation period might be estimated at about five months, which, considering the warm climate of Dade County, seems very long.

The newly hatched specimens measured 55 mm. in length; one is puzzled how such a large larva could have been packed in the small egg from which it hatched, without appreciably increasing or expanding the egg envelope, yet the tough egg capsule showed no distension from the embryo within. The larvae were black above with tan colored bellies and white gills. Under magnification the upper parts, tail and chin appeared dusky with numerous tan and brownish blotches and a scattering of white dots. Two rows of whitish dots extend along the lateral line organs. The lower half of the sides from the front to the hind legs was dull reddish, suffused with melanophores and white dots; the belly was pale tan, with a white line extending medially to the vent. The chin was dusky with a greyish throat. The three gills on each side of the head were colorless

except at the bases where there were some black melanophores. On the side of the speci-
men examined, the gills had 4–7–7 prongs respectively, and the three gills on the other side
have 4–8–8 prongs from the anterior to the posterior gill. The fore and hind limbs are
functional and are used in walking. Each limb is terminated by two toes.

Hildebrand (1910, Proc. Biol. Soc. Wash., 23: 10) reports *Amphiuma means* eggs
on July 24 at Hamburg, S.C., containing large embryos. This date indicates a laying
period of about one month later for this species in the northern part of its range.

A comparison of the egg laying date of *Amphiuma means means* and *A. m. tridacty-
lum*, indicates a different breeding period for the latter. Cope, quoting O. P. Hay, de-
scribes a clutch of *tridactylum* eggs, containing large embryos 45 mm. in length, taken
on Sept. 1, 1887, at Little Rock, Ark. Percy Viosca, Jr., tells me he found the eggs
of this species in the middle of October, near New Orleans, La. These dates imply a
later egg laying period for *tridactylum*, perhaps May instead of January as for *means*.
It is evident that further data on the nests and larvae of these remarkable salamanders
are to be desired. The above notes amplify my letters to S. C. Bishop on this topic
(Bishop, 1943, Handbook of Salamanders: 53–54).—JAY A. WEBER, *10801 Biscayne Blvd.,
Miami, Florida.*

NOTES ON MATING AND MIGRATION IN BERLANDIER'S TURTLE.—On
August 11, 1938, while riding along a trail through thick mesquite and cactus brush in
Brooks County, Texas, approximately 25 miles southwest of Falfurrias, two individuals
of *Gopherus berlandieri* (Agassiz) crawled out of the brush along the trailside, one ap-
parently fleeing, the other in pursuit. The pursuer caught up with the leading tortoise
in the middle of the trail and proceed to mount in normal tortoise copulatory fashion.
Circumstances prevented further observation, but it seems reasonable to assume that
the leading tortoise was a female, the following one a male. The speed of locomotion
seemed to be much faster than the normal gait of these animals.

August 3, 1938, while driving along U.S. Highway 96 between Skidmore, Bee Coun-
ty, and Mathis, San Patricio County, in the vicinity of Corpus Christi Lake, an ap-
parent migration of this species was observed. Sixteen of these tortoises were counted
on the road alone in a distance of 2 or 3 miles, and at least as many more were ob-
served in the sandy, brushy country beside the road. This was just after the let-up of
the disastrous flood rains which devastated North Texas that year, this part of Texas
also receiving a part of these rains, and the surrounding country was quite damp.

It may be of interest to note that people driving along the road seemed to derive
pleasure from running down these reptiles, as several crushed specimens were seen. The
animals seem to fly apart with a slight "pop" when hit. These tortoises may therefore
be added to the list of our native animals whose numbers are being depleted by the
automobile. Klauber (1932, COPEIA, 3: 128) mentions crushed shells of *G. agassizii* ob-
served by him in California. These possibly were the result of similar encounters between
motor-car and tortoise.

The majority of the specimens seen were headed east in a general way, though they
might be pointed in any direction from NNE to SSE. It is quite possible, however, that
this impression of unanimity of direction may be in error, since no special effort was
made at the time to determine the direction of the movement. The tortoises may have
been moving away from Corpus Christi Lake. They were moving as individuals, not as
a group, nor in small groups. Specimens collected are in the Carnegie Museum.

Major Chapman Grant (1936, Zoologica, 21: 227) reports that he has seen what
appeared to him to be a migration of this species in southern Texas. He does not give
particulars.—RODGERS D. HAMILTON, *Biological Laboratories, University of Rochester,
Rochester, New York.*

ADDITIONAL RECORDS OF THE SCARLET SNAKE IN NEW JERSEY.—
Since the first definite record of the scarlet snake, *Cemophora coccinea* Blumenbach, in
New Jersey was reported (1935, COPEIA: 191) at least four additional specimens have
come to light in three southern counties of the state. Mr. Asa Pittman, who secured
the two original specimens at Whitesbog, Burlington County, found an adult (Zool. Soc.
Phila. No. 2149) east of Upton on N. J. Route 40, in Burlington County, near the

Burlington-Ocean County line, on May 28, 1940. Mr. Hollis Koster collected a specimen (Z. S. P. 2661), DOR, at Green Bank, Burlington County, on July 30, 1940. The late Mr. Ladd of Vineland had a specimen brought to him from the Vineland region, Cumberland County, during June, 1940. This is now in the collection of the American Museum of Natural History (No. 63858). Another snake of this species was collected near a cranberry bog at Pleasant Mills, Atlantic County, July 7, 1941, by Miss Patsy Shina, and is in the collection of the Newark Museum. At least one additional specimen, possibly two, said to have been collected by members of the Civilian Conservation Corps at Mount Misery, Burlington County, did not find their way into any collection to our knowledge. A summary of the characters of the six known specimens is given below. All have the scale rows 19–19; the oculars 1–2 on each side, and the anterior temporal single.

Mus. No.	Sex	Ventrals	Caudals	Labials Upper	Labials Lower	Temporals Ant.	Temporals Post.	Blotches Body	Blotches Tail	Total Length	Tail Length
A. M. N. H. 58070	♂	164	38	6	7	1	2	15	4	178	26
A. M. N. H. 58071	♂	163	44	6	7	1	2–1	15	4	163	25
A. M. N. H 63858	♂	163	39	6	7–8	1	2	19	6	489	72
Z. S. P. 2149	♀	161	37	6–7	7	1	1			502	65
Z.S.P. 2661	♂	158	40	—	—	—	—	15	3½	420	53
Nk. Mus.	?	154	40	6	7–8	—	—	19	6	358	48

Carl F. Kauffeld, *Staten Island Zoological Society*, and Harold Trapido, *Department of Zoology, Cornell University, Ithaca, New York.*

NOTES ON *NATRIX HARTERI* IN CAPTIVITY.—Two adult *Natrix harteri* Trapido were received from Mr. Philip Harter on July 20, 1942. They were from the type locality, Palo Pinto, Texas. Both specimens were female, obviously gravid.

The larger of the two, 798 mm. long, died on August 2, 1942. Sixteen half-developed embryos were present in the oviducts. The smaller female, measuring 753 mm., gave birth to a young snake, fully-developed, but dead, on September 16, 1942. Two days later the mother snake died of a lung infection. There were twenty-two well advanced embryos in her oviducts. They averaged 200 mm. in length; the shortest was a deformed specimen of 174 mm.; the longest measured 216 mm. These embryos were like the mother in color and pattern. The yolk had been almost entirely absorbed. The hemipenes of the males were not everted, as is usual with premature young at an earlier stage. Twenty specimens of this species have been under my observation. The following items of food have been accepted: salamanders (*Desmognathus f. fuscus, Eurycea bislineata*), frogs (*Rana s. sylvatica, R. clamitans, R. catesbeiana,* and tadpoles of the latter), and fresh and salt water fish (perch, smelts, and killfish). One specimen ate a small crayfish. —James McCallion, *38 Moody Place, Staten Island, New York.*

A TERATOLOGICAL SPECIMEN OF THE TIGER SALAMANDER.—On August 22, 1939, I collected a tiger salamander (*Ambystoma t. tigrinum*) about 12 miles north of Detroit Lakes, Minnesota, which was unusual in having the left forelimb duplicated. The additional appendage possessed seven toes instead of the usual four. When alive the specimen did not seem to be capable of moving the accessory appendage independently. The extra limb appeared to be used only in conjunction with the normal limb and for the most part was of little aid in locomotion. It seems probable that the innervation of the two limbs was not entirely separate.

Dissection of the specimen showed the pectoral muscle of the left side to be modified for attachment to the extra limb. The hypaxial trunk muscles in the region of the extra limb were also slightly modified for attachment to it. Although the extra appendage possessed a scapula, no additional coracoid bone was present.—John A. Sealander, *Detroit Lakes, Minnesota.*

THE HATCHING OF *ELEUTHERODACTYLUS PARVUS* GIRARD.—A clutch
of small *Eleutherodactylus* eggs was found by Professor Adolpho Lutz, J. Venancio and
myself in a low bank of earth on the Tijuca Mountains at Rio de Janeiro, Nov. 19, 1937.
There were ten eggs, grouped together rather like a mulberry. The eggs were rounded,
enclosed in gelatinous double coats, respectively 5 and 4 mm. in diameter. There was
no foam, nor were they by the waterside. Black eye spots, the rounded outline of the
snout, and legs with perfectly formed toes were visible in the well-developed embryo.
These parts of the body were light gray. The forelimbs were less marked and very
translucent. The heart was quite conspicuous. The body was curved round the cream
colored yolk, with the feet pointed towards the chin, the heart under it and the fore-
limbs to the sides of it.

We took the eggs home and managed to keep them alive. Occasionally the eggs
were convulsed by the movements of the embryos. Thirteen days later, December 2,
they hatched. When we arrived at the laboratory one of the little frogs was already
out of the egg and was trying to climb up the glass wall of the vivarium which was
filled with damp moss. It easily jumped 10 to 20 cm. The clutch was then observed
with a binocular microscope and a few photographs were taken. In a few minutes an-
other little frog hatched. It first pushed out the egg shell with its hands and feet, then
tore at it with the hands and snout (armed with an egg tooth). A moment later it was
outside and jumped 10 cm. away. Three minutes later it was leaping about, 30 cm. at a
time. The next one was lying on its back, with the egg yolk and the pulsations of the
heart quite visible. A vigorous thrust pushed its hind limbs out of the shell. Another
extended them full length and the froglet tumbled out. It lay on its back for a moment
and then turned over and jumped off. At the same time another one was trying to push
its head out of the egg. While lying under the camera it tore the shell with its head
and hands and stepped out. Five others hatched during the day. Shortly before emerging
one was seen with its snout closely applied to the shell. The last was killed and fixed
inside the egg. The egg tooth, which is afterwards shed, was then visible.

At the time of hatching the body is quite oval and the digestive tract encloses the
remnants of the yolk. The body is very translucent. The whole dorsal aspect is covered
with black dots on a metallic brown field. One showed a light mid-dorsal line. Another
had a white canthal stripe from the tip of the snout to the eye. Faint cross bars on the
hind limbs could be seen with the aid of the microscope. There was no vestige of a tail.
They were 5 mm. long. During the next days all the little frogs began to show the
characteristic shape and color, including the very noticeable black anal region, of the only
small species of *Eleutherodactylus* found near Rio. Professor Lutz and I refer it to
Eleutherodactylus parvus Girard. The name *E. rhodopis* has been erroneously applied
to this species.—BERTHA LUTZ, *Museu Nacional, Rio de Janerio, Brazil.*

THE PILOT BLACK SNAKE IN MINNESOTA.—No published records have ap-
peared for the pilot black snake, *Elaphe obsoleta obsoleta* Say, from Minnesota although
it was known to occur in southwestern Wisconsin and northeastern Iowa. On October 2,
1942, W. J. Breckenridge, John Dobie, and Clarence Velat, collecting for the Depart-
ment of Zoology and the Minnesota Museum of Natural History of the University of
Minnesota, encountered two DOR specimens of this snake in Houston County south of
Reno. One, a female in good condition (MMNH No. 1178), was a little under 5
feet in length (143 cm.). It has the following scutellation: ventrals 234, caudals 66;
scale rows 25–27–23–19, upper labials 8–8, lower labials 11–11; head plates atypical, the
preoculars on both sides being almost completely divided, and the lateral extensions
of both prefrontals completely separated from the prefrontals proper, giving the ap-
pearance of two loreals. The caudal count is unusually low. As Dr. Reeve Bailey of
Iowa State College reports that only slight indications of these variant characteristics
are to be found in his material from northeastern Iowa, the specimen is considered
simply as an aberrant individual. The other DOR specimen was slightly larger but in
an advanced stage of decomposition and was not preserved. A third specimen, in the
possession of Emil Liers of Homer, Minnesota, was examined and identified; it had
been secured at about the same place in Houston County on September 16 and turned
over to Mr. Liers. This specimen later was sent alive to Lew Johnson at Ashland,
Wisconsin.—W. J. BRECKENRIDGE, *Minnesota Museum of Natural History, University of
Minnesota, Minneapolis, Minnesota.*

REVIEWS AND COMMENTS

STATISTICAL ADJUSTMENT OF DATA. By W. Edwards Deming. John Wiley & Sons, New York, 1943:I–X, 1–255. $3.50.—This book is written with the assumption that the reader is well familiar with the calculation and use of the conventional statistical tools. Inspired largely by Shewhart's concept of control (the application of which to fishery biology has been demonstrated by Rich), it takes up statistics from the viewpoint of the adjustment of data. This the author defines as the "estimation in which the end product is a set of *adjusted values,* which have been forced . . . to satisfy certain conditions."

The preface says, "The student is first introduced to some basic statistical concepts, and in particular he is asked to view a method of adjustment as a way of arriving at a figure *that can be used for a given purpose*—in other words, for action . . . For the first time, a method for adjusting the observations (finding the calculated points corresponding to the observed points) is provided for the circumstance in which both the x and y coordinates are subject to error. The insidious phenomenon of the instability of equations is introduced, even though inadequately, and the reader can at least claim acquaintance with it. . . . Different kinds of problems of adjustment (e.g., goedesy on the one hand and curve fitting on the other) are here unified and brought under one general principle and one solution . . . the reader will find contributions from (the fields of statistics, least squares and curve fitting) and he will perceive that all three groups are complementary."

As desirable as all this is, the presentation of it is so obscured by the author's esoteric viewpoint that it is exceedingly difficult to follow. This results, I think, more from hurried, even unsympathetic writing than from a super-recondite quality of the ideas or methods described. It is to be hoped that the author will try again, when the present edition has been sold, and take more time in the task, for there is certainly need of a book covering this subject matter.—L. A. WALFORD, *Stanford University, California.*

THE FRESH WATER FISHES OF CHINA. By John Treadwell Nichols. Natural History of Central Asia, Vol. 9. American Museum of Natural History, New York, 1943. Paper-bound $9.00, cloth, $10.00.—Mr. Nichols' handsomely illustrated, monumental work is an account of the known fresh water fishes of China proper, exclusive of such outlying territories as Manchuria and Mongolia. The material for the study has been furnished by the collections of the Asiatic Expeditions of the American Museum of Natural History. These constitute the most comprehensive assemblage of Chinese fishes in existence.

The scope of the work covers all the known forms; brief comparative descriptions of the genera and species are given; and keys to the species are furnished wherever more than one species occurs in a genus. This is a fine contribution to our knowledge of Asiatic fishes, and a handsome book.—L. A. WALFORD, *Stanford University, California.*

STATISTICAL ANALYSIS IN BIOLOGY. By K. Mather. Interscience Publishers, New York, 1943:1–244. $4.50.—This book illustrates with biological problems, the application of statistical principles and methods as set forth by R. A. Fisher. The aim of the author is to show the scope of the various methods, how they are interrelated and how they fulfil the conditions necessary for satisfactory analysis. Of particular interest is a section on discriminant functions, a useful device for racial studies. In a foreword to the book, R. A. Fisher says "It is very simply written, and by well-chosen examples exhibits every step of the processes needed. The careful reader should rapidly acquire a repertoire of techniques appropriate to very varied circumstances." In the face of this comment by so eminent an authority, I hesitate to say that I found the book hard to follow, owing entirely to its heavy attempt to be simple.—L. A. WALFORD, *Stanford University, California.*

THE LIZARDS OF SOUTH AFRICA. By Vivian F. FitzSimons, Transvaal Museum Memoir No. 1, Pretoria, 1943: xv + 528, 384 figs, xxiv plates, 1 map (No price stated).—Those acquainted with the valuable contributions to South African Herpetology which have been coming from Dr. FitzSimons' pen (1930–41) have been eagerly anticipating publication of the present volume. Nor will they be disappointed for this treatise is the first comprehensive regional work dealing solely with lizards for any part of Africa, and as such forms an important milestone in African herpetology.

Listing as it does 276 species and subspecies, the book nearly doubles the number recognized by Boulenger in his 1910 list covering the same area, viz. Africa south of the Kunene and Zambesi rivers. Of these 276 forms FitzSimons himself has described no fewer than 43, the majority of which will undoubtedly stand the test of time. A further 60 forms recognized were named by Dr. John Hewitt, another very active South African zoologist.

Keys supplied to aid in identification of species are beautifully clear. They appear, however, to be based on characters selected for convenience rather than chosen to reveal probable lines of descent. One objection to such procedure lies in the tendency to separate widely forms which are closely related in all but the key-character. Should that character ultimately prove to be unstable, confusion results. Such an objection loses part of its weight if the detailed accounts of the species are arranged according to their probable affinities. Where they follow the format of the artificial key it results in a meaningless assemblage that is especially noticeable in the larger genera. An illustration of this is furnished by the genus *Pachydactylus* (41 forms) where *microlepis* Hewitt is separated by 12 species or races from *maculatus* Gray, of which it may well be a synonym, while 3 relatively remote forms are interposed between *robertsi* FitzSimons and *scutatus* Hewitt, whose relationship is so close that it may well prove to be subspecific.

A bibliography of the more important references is given for each species or race. This is followed by a detailed description, the portion dealing with color often based on that of living lizards secured by the author during his numerous expeditions. One observes with particular appreciation the inclusion of interesting notes on habits—too often omitted from works of this nature.

In the face of so much concrete evidence of an author's painstaking industry, it seems ungrateful to point out flaws which, in this case, are like the proverbial needles in a haystack. It was no easy task which FitzSimons has tackled and as one turns over the 500 odd pages it is obvious that he has performed a signal service to his fellow herpetologists in completing it. No worker on African lizards can afford to be without a copy for it is likely to remain the standard work on the South African species for very many years to come.

This fact makes it unfortunate that a further lease of life has been given to certain much used but obsolete names. *Pachydactylus ocellatus* (not of Cuvier, 1829) was shown by Andersson (1900) to be a synonym of *geitje* Sparrman (1778), and *Agama atricollis* A. Smith (1849) by Parker (1942) to be antedated by *cyanogaster* (Rüppell, 1835). Both *Rhoptropus* and *Rhoptropella* have been deprived of their first 'p' throughout the text, including original citations. From the synonymy of *Gerrhosaurus f. flavigularis* (p. 272) one misses Cocteau's *ocellatus* from the Cape, and Boettger's *quadrilineata* from the Orange Free State, while in the same synonymy the references of two misspelt species of *Pleurotuchus* have been compounded, possibly by the printer. Total elimination of some errors of this nature from so large a work are next to impossible and should not be considered as detracting from its usefulness to any appreciable extent.

The value of the book is enhanced by 384 (not 379 as stated on title page) excellent text figures, also the numerous plates, most of which are admirably clear, a few rather indistinct. Herpetologists who have searched ordinary atlases in vain for certain place names, will welcome the detailed map at the end of this volume and even more the splendid gazeteer listing over a thousand South African localities in which lizards have been collected. The Trustees of the Transvaal Museum are to be congratulated on producing this first volume in a series of new memoirs.—ARTHUR LOVERIDGE, *Museum of Comparative Zoölogy, Cambridge, Massachusetts.*

HANDBOOK OF SALAMANDERS: THE SALAMANDERS OF THE UNITED STATES, OF CANADA, AND OF LOWER CALIFORNIA.—By Sherman C. Bishop. Comstock Publishing Co., Ithaca, N.Y.: XIV + 555, 144 figs. 1, pl., 55 maps, $5.00.— Dr. Bishop's work on the salamander fauna of North America has long been eagerly awaited by his colleagues, since many of us have known of its progress, of the new studies being incorporated into it, and of the special interest in this group shown by the author in various earlier publications. The handsome volume now before us fully describes the rich salamander fauna of North America, north of Mexico, and including the Mexican territory of Lower California. Every species is figured and its geographic range is mapped. The result is a work to be recommended to every naturalist in North America who wishes to explore his local region for these creatures, many of which have remarkable breeding habits or other features of special interest. The species can readily be identified by means of the new book. The descriptive matter is clearly organized, under the successive headings, common name, scientific name, type locality, range, habitat, size, description, color, breeding, and larvae. With respect to form and clarity of treatment, as in typography and illustration, the work leaves little to be desired.

Within the framework set for his treatment of the salamanders of North America, I find little criticism of the *Handbook of Salamanders*. The keys for identification are clear but far from simple and could be improved by a special section on their technical anatomical terminology, or by the effective device of illustrating the keys themselves. The maps need explanation and interpretation, and would thus become more meaningful. The bibliography and index are adequate.

To a naturalist in search of an ideal treatment of an order, however, the plan of the work falls short of its author's abilities. The book is focussed too much on identification, as if animate creation existed only to be named. The introduction is disproportionately short; it should have given some account of the salamander fauna of the world, and of the remarkable fact that this primitive group is almost entirely confined to the northern hemisphere. The broader biological interests should have had more extended treatment; neoteny, for example, deserves more than a fraction of a page.— KARL P. SCHMIDT, *Chicago Natural History Museum, Chicago, Illinois.*

EDITORIAL NOTES AND NEWS

News
Notes
DR. PETER J. SCHMIDT has written recently that he and DR. LEO BERG, honorary foreign member of our Society, are in good health, and, after many harrowing months at Leningrad, have reached a health resort in western Siberia, where they are studying and working as much as possible in the absence of laboratories and libraries. They will appreciate receiving scientific publications, as well as general magazines, and even American newspapers of recent date, as they have no foreign literature. Dr. Schmidt writes "Please give my best greetings to the members of the Society, among whom I have so many friends! I hope sincerely that after victory, that now must be near, our connections and scientific cooperation will be more intimate and deep than before."

On November 26, 1943, at Baltimore, Maryland, a 10,500 ton Liberty ship was launched in honor of the late DR. HUGH M. SMITH, ichthyologist and former United States Commissioner of Fisheries. Miss Alice Cowdry, granddaughter of Dr. Smith, christened the new ship U.S.S. "Hugh M. Smith." Mrs. Alexander Wetmore and Dr. and Mrs. Leonard P. Schultz represented the Smithsonian Institution at the ceremonies.

J. LINSLEY GRESSITT, of Lingnan University, Canton, his wife and baby daughter, and DR. ALICE BORING, of Yenching University, Peiping, have been repatriated from Japanese occupied territory in China, returning home on the "Gripsholm." Mr. Gressitt writes from the University of California, Berkeley, that he and his family are well.

DR. CHARLES M. BREDER, formerly Director of the New York Aquarium, has been appointed Curator of the Department of Fishes of the American Museum of Natural History. CHRISTOPHER W. COATES, a member of the aquarium staff, has been appointed Curator of Fishes at the Zoological Park, and DR MYRON GORDON, also an aquarium staff member, has been made assistant curator.

DR. CHARLES HASKINS TOWNSEND, for 35 years (1902–1937) Director of the New York Aquarium, died on January 12, aged 85.

MR. W. J. PHILLIPPS, formerly of the Dominion Museum, Wellington, New Zealand, is now acting as mosquito-control officer for the New Zealand Department of Health. Mr. Phillipps prepared a bibliography of New Zealand fishes and was publishing a book on the fishes of that country but publication has been suspended until the end of the war. Mr. Phillipps had experience in mosquito control in Cairo during the last war, and was responsible for the introduction of *Gambusia* into New Zealand, a measure which proved a successful means of mosquito-control in many parts.

We learn that PROF. A. THEODORE MONOD, Directeur de l'Institut Français de l'Afrique Noire (Dakar, Sénégal, French West Africa), escaped from Paris in November, 1942, and is now actively continuing his ichthyological work at Dakar. He is giving particular attention to the fish fauna of the Niger. Dr. Monod is anxious to receive again publications from his American colleagues.

DR. ETHELYNN TREWAVAS writes that a long illness prevented him from finishing the Fishes Section of the 1942 *Zoological Record* in time for its inclusion. He hopes to finish a double section (1942 + 1943) by midsummer.

ROBERT R. MILLER has been appointed Associate Curator of Fishes at the National Museum, and will take over his new duties June 1.

CHAUNCEY JUDAY, Professor of Limnology at the University of Wisconsin, died on March 31, following an illness of several weeks. With E. A. Birge, he played a pioneering and a preeminent part in the development of pure and applied limnology in America. He personally carried on and extensively sponsored researches on the production, growth and distribution of Wisconsin fishes.

The Editors gratefully acknowledge the aid received in printing this issue of COPEIA from DR. SHERMAN C. BISHOP and from the SPECIAL GIFT FUND of the Society.

Honor   ADDITIONS to and changes in the HONOR ROLL of Society mem-
Roll   bers in the United States armed services are: LT. JOSEPH R.
BAILEY, Army Air Corps; DAVID BIERHORST, U. S. Army; LT. JOHN DAVIS, Army Medical Corps; SGT. CLIFTON M. GREENHALGH, Army Medical Corps; LT. EARL HERALD, U. S. Army; CAPT. ROBERT J. SLOCUM, U. S. Army; TECH. SGT. FRANCIS H. SUMNER, Army Medical Corps; CPL. LLOYD TEVIS, JR., U. S. Army; SGT. E. H. VESTAL, U. S. Army.

Errata   IN THE obituary note on CHARLES TATE REGAN, by DR. ETHEL-
                   WYNN TREWAVAS, COPEIA (3), 1943, the following changes should
be made: p. 202, line 22, for 1908 read 1906; p. 203, line 2, for Royal Zoological Society read Royal Society; p. 203, line 14, for deep angler fishes read deep sea angler fishes, p. 204, line 4, for angle read angler.

The price of the fifth edition of *A Check List of North American Amphibians and Reptiles*, by LEONHARD STEJNEGER and THOMAS BARBOUR, is $2.50, instead of the $4.00 announced in the Review of this book in COPEIA (3), 1943: 200.